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BENTHIC ECOLOGY OF DUBLIN BAY IN RELATION TO SLUDGE DUMPING: FAUNA

Benthic ecology of Dublin Bay in relation to sludge dumping: Fauna.

by

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ABSTRACT

The Dublin Bay area in 1971 received sewage from about three quarters of a million people most of which was discharged or dumped off Howth to the north-east of the bay. Much sludge appeared to settle up and down the tide from the dump site, though finer particles entered the bay to the south. Additionally, dredge spoil was dumped south-east of the Baily up to 1971, but not in 1972. In 1971 and 1972 the effects of these organic wastes on the benthos were investigated.

The fauna in the main part of the bay resembled the *Acrocnida/Clymene* community of Glémarec. On the sand banks there were also species of the *Ophelia* facies of Glémarec's deep *Venus* community. In the dumping area and in the south-east of the bay downtide of the dump site, where depths are greater, the faunas resembled the *Nucula/Sabellaria* community of Caspers. As well as having pollution indicator species, this latter community generally had greater faunal densities and diversities than elsewhere in the bay (except low diversities at the dump sites in 1971). Apart from a possible effect of depth, this suggests that the dumping was having an enriching rather than a degrading effect, although the probable sediment change since 1874 may imply a change in community type.

Microvores (comprising surface-deposit and suspension feeders) were a prominent isotrophic group in the sampling area, and at the sludge-dumping site in 1971 particle feeders were abundant. All feeding types were more numerous in the organic waste settlement areas, though proportionally they appeared to be receiving differential benefits from the sludge and dredge spoil.

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INTRODUCTION

Sewage sludge and dredge spoil have been dumped in the Dublin Bay area for many decades, and there is no pre-dumping quantitative benthic data for close comparison with this study, though earlier work does give clues to previous situations (Southern, 1910; Massy, 1912; Abdel-Moez, 1957; Naylor, 1965). Additionally, an up to date natural history of the area will be found in Jeffrey (1977). The sampling for our study took place in May and July 1971 (the main survey), and in July 1972, and the conclusions will thus be based on spatial rather than temporal variations in the fauna. The benthos inhabiting the suggested paths of the settling sludge and dredge spoil (see Rees and Walker, in press) will be compared with that in other areas within the sampling grid.

Pollution load, hydrography and sediments in Dublin Bay are considered in another paper (Rees and Walker, in press). This is summarized as follows. In 1971 the Liffey Estuary and Dublin Bay area (Fig. 1a) received sewage from about three quarters of a million people. Primary settled sludge from rather less than half of this population (about 140,000 wet tonnes per year) was shipped from Pigeon House Dock in the mouth of the Liffey to a site about two kilometres east of Howth (sites Z14 and A14, Fig. 1b), where it was dumped at sea. Sewage from somewhat under a third of the total population was discharged from the north coast of Howth, just east of the harbour and therefore outside Dublin Bay. Sewage from a further sixth was discharged into the mouth of the Liffey (Rathmines and Pembroke outfall), while two more outfalls with lower contributing populations discharged from the south coast of the bay (West Pier Dun Laoghaire and Bullock Harbour). In addition, dredge spoil from the estuary was dumped at sea about a kilometre south-east of the Baily (site B12, Fig. 1b) up till the end of 1971.

As the loading berth at Pigeon House Docks is tidal, sludge is dumped near high tide. Distribution patterns of tomato pips and other sediment characters show that initial movements of suspended sludge are mainly south across the bay mouth, but current meter observations and sea bed drifter recoveries show northward residual water movements (Rees and Walker, in press). Thus the sludge appears to settle up and down the tide from the dump site. Much actually settles on the sea bed at the site itself, but such settlement may not necessarily be immediate, the particles having moved to and fro with the tide for a while (Rees and Walker, in press). Owing to its configuration the bay itself has a strong clockwise residual circulation, and some of the finer sludge and dredge spoil particles were found to be entering to the south. The estuary water is dispersed without it having much influence on water quality in the bay, the main mixing of the sea and brackish water occurring within the port breakwaters.

Dublin Bay is a shallow sandy bay protected from wave disturbance of the bed by both the land and linear sand banks offshore (Fig. 1a). Poorly sorted sediments with mud, stones, shell and cinders occur around the sludge and dredge spoil dumping grounds. Comparison with the 1874 chart notations suggests that mud was previously absent in the scour depression east of Howth Head where now most of the sludge probably settles. Mud also occurs in the deeper southern part of the bay, probably also originating from the dumping (Rees and Walker, in press), but most of the bay has moderately clean very fine to fine sand apart from the medium sand of the banks.

In this study four approaches are considered in an investigation of the effects of organic pollutants on the benthos of Dublin Bay. Communities and sample population structures are examined, the distributions of the indicator species present are investigated, and finally feeding habit division is analysed. While any one of these approaches may give meaningful results in some cases, in other cases one method alone may not be adequate (Gray, 1976). Therefore an attempt is here made to examine the same faunal data in four different ways in order to build up a composite picture of the effects of the dumping.

Community analyses

Petersen (1913, 1918) working in the northern hemisphere found that the various species tended to live in more or less discrete groups or communities. The distribution of such communities may be correlated with habitat factors (Jones, 1950; Thorson, 1957; Glémarec, 1973), and in this way groups of species can be used as an approximate measure of various environmental characteristics. Quantification of this synecological approach, however, has led to a multiplicity of methods of analysis, with no one predominating at present (e.g. Sanders, 1960; Field, 1971; Hughes and Thomas, 1971; Stephenson and Williams, 1971; Hill, 1973a; see also Greig-Smith, 1964). Methods of analysis are basically of two types: classification and ordination. In the former method pairs or groups of individuals (stations or species) are progressively clustered into larger and larger groups producing a dendrogram. Ordination (Goodall, 1954) involves plotting stations or species along axes of variation in the data.

Sample structure

In the sample structure approach, numbers of individuals and species are counted, and the relationship between these two faunal variables may be expressed as a diversity index (Sanders, 1968; Gray, 1974). Some indices state by means of a single figure the proportional abundance of species within a sample. These are

termed species diversities (Whittaker, 1965). Other indices (also with a single figure) go further, and include the notion of equitability (Lloyd and Ghelardi, 1964). These are termed dominance diversities. Whittaker (1965) considered that a single figure was inadequate to quantify diversity. Gray (1974 and 1976) is also critical of the concept. However, use of diversity in conjunction with other approaches has shown it to be empirically useful. Sanders (1968) found species diversity more constant than dominance diversity in its relationship with the physical environment. Low diversities *sometimes* indicate environmental degradation.

Indicator species

Organic waste is highly reducing in nature, due to the presence of aerobic bacteria. If enough oxygen is not available such waste is also decomposed by anaerobic sulphur bacteria releasing hydrogen sulphide. Meanwhile enormous quantities of organic matter may be available as food for any organisms that can utilize it while withstanding the resulting environmental conditions (Reish, 1959; Stirn, 1970; see also Korringa, 1968). Such 'pollution indicator species' must have a wide though not necessarily dense distribution in non-polluted areas in order to be able to capitalize on newly or intermittently polluted regions (Eagle, 1974). An often used alternative term to indicator species is transgressive species (Tulkki, 1968). Such species spread into polluted regions. This author defined as regressive those species which retreat or disappear from such regions, and those whose distribution was unaffected by pollutants he described as indifferent.

Feeding types

Most indicator species are particle or detritus feeders, though there are several carnivorous exceptions (for example see Pearson, 1975, Table VIII). It is therefore highly feasible that a large numerical increase in particle feeders in a particular area, together with an actual or proportional decline in carnivores, may be indicative of organic pollution, or enrichment, a step from such deterioration. Pearson (1971a) found surface-deposit feeders to be positively, and carnivores negatively, correlated with the organic silt of a Scottish sea-loch system. However, this environment is more complex than the benthic ecosystem of Dublin Bay, with which direct comparison would be unreasonable. From studies on lake ecosystems it appears that as organic input increases, trophic relationships are simplified (Lindeman, 1942). The complicated food webs at the oligotrophic end gradually give way to simplified communities (entirely detritus feeders) of lower 'biological efficiency' at the eutrophic (or hypertrophic) end. The fact that some marine pollution indicator species are carnivores, maybe feeding on unsampled meiofauna, means that this 'carnivore exclusion with excessive enrichment' hypothesis may not work in all cases in the sea. But it should prove useful in many studies. (c.f. Seymour, 1976). Pearson and Rosenberg (1978) further discuss trophic groups in this context.

SAMPLING PROGRAMME AND SORTING METHODS

Three main cruises were made for the collection of samples. Two, in May and July 1971, were made in R.V. "Cú Feasa" during which the bay and several stations around the sludge-dumping site were sampled. The final cruise was made in July 1972 on board R.V. "Cú na Mara", when several repeat samples were taken, and the sampling area was also extended farther north to cover more of the area within the tidal excursion from the dump site. For sampling purposes Dublin Bay was considered to be overlaid by a grid based on the intersects of the red and green Decca chain 3 lines. The east-west lines were each given a letter, starting with U in the north down to Z, then A to J in the south. The lines crossing these (approximately north-south) were numbered from 3 in the west, to 18 (Fig. 1b). For the 1972 samples a 2 was used as a prefix to the station code (e.g. 2J14). The year(s) when stations were sampled can be found from Figs. 2 and 3.

A Smith-McIntyre grab (0.1 m^2) was used to sample all but four northerly stations at the end of the 1972 cruise, when this was damaged and a Van Veen grab (0.1 m^2) was used. Normally, but not always, two grab lowerings or dips were made at each station. The samples were then emptied into plastic baths for transfer to a wide mesh screen mounted in a hopper. From the first (or only) grab sample at each station a small sub-sample was taken for sediment analysis (Rees and Walker, in press). The samples for faunal analysis were washed through the wide mesh screen to a 1 mm mesh nylon sieve. Animals retained by the top screen were preserved with the contents of the sieve in 5% formalin.

In the laboratory the fauna was sorted manually, identified and counted (fauna list, plus where appropriate the keys used, in Appendix). Nemertines often posed a problem due to fragmentation. Colonial ascidians, bryozoans, hydroids and species of analogous growth patterns were omitted from the numerical analyses, but are included in the final table in the Appendix.

ANALYSIS INTO BENTHIC COMMUNITIES

Both classificatory and ordination procedures were used here in the analysis of faunal data. Classification illustrates the data as a single diagram, a dendrogram, which shows a simplified relationship between all stations from which broad community groupings may be obtained. It is simplified in that it does not show the similarity coefficients between all stations, as does the trellis matrix from which it is derived. Trellis matrices are usually too complicated to give a useful overall view of the data when there are many stations or samples. Ordination does not illustrate the data in a single diagram, but picks out trends of variation in the fauna which are represented as axes in multi-dimensional space. Up to (usually) three of these may be represented as a three-dimensional diagram, which may give a useful though incomplete picture of the data. The main advantage of ordination is that the axes of faunal variation *may* correspond to trends in environmental variables, such as pollution gradients.

CLASSIFICATION

Method

The method of classification adopted here was that used by Bray and Curtis (1957) and Field and McFarlane (1968). It is based on actual, not relative, numbers of individuals, without standardization. The formula is:

$$C_z = 2W/(A + B)$$

where A is the sum of all the individuals in one station, B is the sum for the second station (only two stations are compared at a time), and W is the sum of the lesser totals (from either station) of each species in the two stations. The group averaging clustering method of Lance and Williams (1966) was used in constructing the dendrogram for the fully identified samples. Not all taxa were included in the analysis, especially where identification was in doubt at the time. Programme GACLUST;DC;60;ALGOL; in the Computing Department, U.C.N.W., Bangor, was used in both stages of this analysis.

Groupings of stations obtained from classification

The dendrogram resulting from the classification procedure is shown in Fig. 2. In such a representation of the results the early fusions of samples, at the highest levels of similarity, are usually taken as less meaningful, being subjected to greater random effects (Gage, 1974). However, the larger groupings may be considered to be ecologically relevant. The dendrogram from the Dublin Bay data shows three main sub-divisions. To the left is Group I, consisting of 39 stations. Next are two non-aligned stations (both 1972, hence the 2 prefix), 2D4 in the Liffey Channel, and 2DL from Dun Laoghaire Harbour. There then follow two closely associated 1971 stations, Z14 and A14 which had very high numbers of *Cirratulus filiformis*. Because the numbers and distribution of the other species in these two stations were similar to those in the following 21 stations, these 23 stations were all considered as Group II. Sample 2X15 from north of the sludge dumping area is a third non-aligned station and finally Group III, consisting of 15 stations, is on the right of the dendrogram.

The distribution of the groups is mapped in Fig. 3. The major part of the bay was occupied by stations within Group I. Group II was found to the north-east and south-east of the mouth of the bay, and also included 2I6, in the mouth of Dun Laoghaire Harbour. It extended as far north as site V15, but sample 2U15 belonged to Group III. Most stations of Group III were sited on the Rosbeg and Burford Banks.

Some physical characteristics of the environments of the associated groups of stations together with faunal data are listed in Table 1. Group I lived in clean to muddy sand in the more inshore parts of the bay down to 24 m. Group II inhabited poorly sorted muddy sand to sandy mud in the deeper regions of sampling area. Stations in Group III came from sand banks with generally clean sands of greater mean grain sizes. The most prominent species in the groups are listed in Tables 2, 3 and 4. Species nearly exclusive to each group are listed in Table 5, while more widespread species will be found in Table 6.

Group I (Table 2) occupied the greater part of the sea-bed of Dublin Bay. No species found at 50 per cent or more of the stations was exclusive to this group, but *Sigalion mathildae* (72% occurrence) and *Acrocnida brachiata* (62% occurrence) were found rarely (less than 10% occurrence) in the other two groups (Table 5). Other important species more common in this group than the others were *Magelona mirabilis, Prionospio malmgreni, Ampelisca brevicornis, Venus striatula* (Table 2). However, the almost exclusive presence of *Acrocnida* in this group, and the common occurrence of *Caesicirrus neglectus* suggests that the group may correspond to the *Acrocnida brachiata/Clymene oerstedi* (= *Caesicirrus neglectus*) community of Glémarec (1969, 1973). This community is a development of the shallow *Venus* or Boreal offshore sand association (see Jones, 1950), inhabiting muddier sediments. Species common to Glémarec's *Acrocnida/Clymene* community and Group I (also cf Appendix) included:

Acrocnida brachiata	*Abra alba*	*Cultellus pellucidus*
Caesicirrus neglectus	*Goniada maculata*	*Lanice conchilega*
Phyllodoce maculata	*Melinna palmata*	*Ampharete acutifrons* (= *grubei*)
Edwardsia sp.	*Ophiura albida*	*Glycera convoluta*
(*callimorpha* here)	*Nucula turgida*	*Lumbrineris gracilis*
Owenia fusiformis	*Nephtys hombergii*	*Tellina fabula*

Many species common to Group I were not found in Glémarec's community (Table 2). There are also some species found in Glémarec's community that were absent in Group I. These are *Amphiura filiformis, Glycera unicornis, Spisula subtruncata, Magelona alleni, Cylichna cylindracea* and *Leanira yhleni*. These differences may be because the Dublin Bay Group I was found in generally cleaner sediments than Glémarec's community, though the vagaries of spat settlement probably also played their part.

Group II (Table 3) showed resemblances to the Boreal offshore muddy sand association, that is, the *Abra* community (Jones, 1950; Thorson, 1957). Four of the species found commonly and almost exclusively in Group II, *Scalibregma inflatum, Ampelisca diadema/tenuicornis* and *A. spinipes*, and *Nucula nucleus* (Table 5), have been used by previous authors to characterise this community. Several other species are common to Group II and the *Abra* community; however, probably the closest parallel with the group is Caspers' (1950) *Nucula nucleus/Sabellaria spinulosa* community. Species prominent in this community and found in Group II were:

Nucula nucleus	*Nephtys cirrosa*	*Ampelisca brevicornis*
Cultellus pellucidus	*Scalibregma inflatum*	*Porcellana longicornis*
Syndosmya (*Abra*) *alba*	*Owenia fusiformis*	*Ophiura albida*
Gattyana cirrosa	*Sabellaria spinulosa*	*Phoronis mülleri*
Pholoë minuta	*Ampharete acutifrons*	*Cerianthus lloydi*
Nereis longissima	*Ampelisca diadema*	*Actinothoë anguicoma*
(probably; here as	(here as *A.*	(here as *Sagartiogeton*
Nereis spp.)	*diadema/tenuicornis*)	*undata*, found once)

Prominent species not found in Group II were *Glycera alba, Lineus bilineatus* (not identified, but may have been present), and *Amphiura filiformis*. Both Caspers' community and Dublin Bay Group II have many rarer species in common, which helps confirm that the communities are virtually identical. Both communities inhabit mixed sediments. There are also similarities between Group II and Glémarec's (1969) *Nucula nucleus* communities.

Group III (Table 4) was found on sand banks of mainly medium sand. It had no species present with more than 50 per cent occurrence that was either exclusive to the group or rare (< 10% occurrence) in the other two groups. Worth noting is the nearly 90% occurrence of *Polycirrus sp. Pearson* (1970) found a *Polycirrus* in gravel and pebble grounds. However, very little of the associated fauna was found in Dublin Bay. The other abundant species in Group III was the ubiquitous *Scoloplos armiger*. Other species present relate the group to the *Ophelia borealis* facies of Glémarec's (1969) deep *Venus fasciata* community, inhabiting medium sand. These were:

Ophelia borealis	*Glycera lapidum*	*Gastrosaccus spinifer*
Travisia forbesii	(= *capitata*,	*Diastylis* spp.
Sthenelais limicola	Hartmann-Schröder, 1971)	*Spisula elliptica*
Nephtys cirrosa	*Lumbrineris gracilis*	*Abra prismatica*

Some of these were here rare (see Appendix). Other species present (Table 4; Appendix) that have been found in coarser sediments included *Pisione remota, Orbinia cuvieri* and *Paraonis lyra* (Southward, 1957); *Astarte triangularis* (Ford, 1923; Smith, 1932; Sparck, 1935), and *Echinocardium flavescens* (in fact here rarer than *E. cordatum*) (Jones, 1950; Thorson, 1957). The nominate species, *Venus fasciata*, was itself found once, but not in Group III. This group contained many species widespread in the sampling area (Tables 2, 3 and 4) and may be considered a mixture of the *Abra* and both shallow and deep *Venus* communities (cf. Jones, 1950; Thorson, 1957).

Thus most of Dublin Bay was found to have a benthic community intermediate between the shallow *Venus* and *Abra* communities, and similar to the *Acrocnida brachiata/Clymene oerstedi* community of Glémarec (1969). Around the dump sites off Howth, and just to the north-east of Dalkey Island, the grounds supported a community similar to the *Nucula nucleus/Sabellaria spinulosa* community of Caspers (1950), while the fauna on Rosbeg Bank and Burford Bank had species found in coarser sediments. The boundaries between the faunal groups in Dublin Bay do not fit in with the classical communities from north-west European shelf waters described in the first half of this century (Petersen, 1918). Any apparent intermingling of the communities may reflect a different distribution of discontinuities in the potential continuum of environmental factors. Additionally, in coastal waters, where the different sedimentary environments are usually found in small patches, the opportunity for cross-invasion of habitats by settling larvae is much greater (Pearson, 1970).

The stations in the above classification analysis which might be expected to have received most sludge and dredge spoil are in Group II. All but one of these stations (2I6) lie in the suggested main path of the settling organic wastes (Rees and Walker, in press). Z14 and A14 (1971) which are very close to the sludge dumping site, were similar to each other and differed from the stations in the group entirely as a result of the super-abundance of *Cirratulus filiformis.* At these two stations the other fauna was normal for the group both in numbers and range of species. With the exception of one 1972 station (2D4) in the channel just seaward of Poolbeg, the stations closest to the mouth of the River Liffey belonged to Group I. From the classification analysis these stations showed little effect that could be related to their proximity to the estuary.

ORDINATION

Method

The method used in the ordination analysis was reciprocal averaging (Hill, 1973a). This method has been used with ecologically meaningful results by Eagle (1974), Hoare and Hiscock (1974), Moore (1974) and Warwick and Gage (1975), and its advantage over standardized principal components analysis is in having species ordinations that accurately reflect the station ordinations. Eagle considers it the best method of ordination from both mathematical and ecological points of view, and from its simplicity of conception. It does have the disadvantage in that downweighting of certain species or stations is usually necessary, thereby losing a certain degree of objectivity. In the programme (EIG;DC;60;ALGOL;) several options are possible. In order to achieve a meaningful distribution of stations along the axes, it was necessary to down-weight rare species and species of high local dominance, together with stations of low Hill diversity (see later). Otherwise certain stations (Z14, A14 and C14) dominate the axes to such an extent that the remaining stations would not be clearly separated (M. O. Hill, pers. comm.). These three stations and *Cirratulus filiformis* (which had high local dominance) all had Hill diversities (diversities for both species and stations are calculated) of less than three, thus this was chosen as the level below which down-weighting became operative. This still allows the above stations to dominate the axes, but there is also a good spread of the other stations.

Grouping of stations by ordination

A three dimensional plot of the station ordinations illustrating the distribution of the stations on the most important three axes is shown in Fig. 4. Only a few of the stations are named in the diagram to avoid confusion. A dashed line separates the three groups obtained by the classificatory procedure. Broadly the stations fit into the groups found by the latter method. Group I stations are closely adjacent to each other on the first two axes, but are of variable values on Axis 3. Of this group, stations B10, C10, D10 and 2C10 have very high values on Axis 3, and in this way resemble stations in Group III. Stations in Group II are more diffusely spread on the first two axes, but tend to have low values for Axis 3, apart from Z14, A14 and C11. The first two of these three 1971 stations dominate the first two axes, and are not very close to the remaining stations of the group. They are also separated in the dendrogram. In both cases this is because of the high dominance of *Cirratulus filiformis.* C11 on the other hand is closer to Group III than Group II, and could well be considered a borderline station. Stations in Group III tend to be diffusely spread on Axis 1, but all have high values on Axis 3. D13, C14, D14, F14, C15 and 2C15 were separated as a sub-group within Group III. Of the three stations that were considered intermediate in the dendrogram, 2DL was here placed in Group I, and 2D4 and 2X15 in Group II. Apart from the above exceptions, the ordination results did not differ greatly from the dendrogram.

Contoured maps for the first three axes (1971 values) are shown in Figs. 5, 6 and 7, and (1972 values) in Table 10. On Axis 1 scores at one extreme occurred at A14 (100) and Z14 (97), in the region of sludge dumping. The contours show a surrounding area with moderately high Axis 1 scores than runs south and spreads in the southern part of the bay. Scores were also relatively higher along the north-west edge of the bay than they were in the middle (Fig. 5). When the direction of residual current is also considered (Rees and Walker, in press) Axis 1 fits in with any possible effect that could have originated from the dumping of sewage sludge, and, to a lesser extent, from the River Liffey.

Axis 2 (Fig. 6) separated stations in the localities of the Burford and Rosbeg Banks from other stations in the sampling area. It appears more closely related to mean grain size than any of the other measured variables (cf. Rees and Walker, in press).

Axis 3 (Fig. 7) shows similarities to Axis 1 in its alignment south from the dumping grounds, but one extreme value (0) occurs at the dredge spoil dumping site (B12) rather than at the sludge dumping site. The contours also show more of a trend into the bay back towards the mouth of the Liffey (Poolbeg). To some extent this resembles the percent volume of fines and sorting coefficient patterns (Rees and Walker, in press), and appears partly to represent an effect of dredge spoil disposal.

The computer placed stations B12 (the dredge spoil disposal site) and 2B12 much closer together (Fig. 4) than A14 (the sludge dumping site) and 2A14, even though dredge spoil disposal had ceased when 2B12 (1972) was sampled. Yet there was no such change in the pattern of sludge dumping. However, the disposal of dredge spoil had ceased only a few months before the 1972 sampling, and the benthic fauna was likely to retain a residual effect. At the sludge dumping site in 1971, station A14 was distinguished by the very large numbers of *Cirratulus filiformis*. In 1972 this station was more similar to the other stations in the sludge dumping area (Table 10). This faunal change is unexplained.

This circumstantial evidence therefore suggests that Axes 1 and 3 may represent effects in the fauna either brought about by the dumping of waste, or by factors that also relate to the pattern of dispersal and settlement of material from the dump sites.

Correlations of the ordination axes.

All the variables investigated in this study including loss on ignition (1972 only) were subjected to a correlation procedure at the U.C.N.W., Bangor computing laboratory. In the procedure were included 70 stations, those samples where only one grab lowering was taken being omitted. The resulting half-matrix is shown in Table 7. Results from correlation must be viewed with caution since the method overrides exceptions unless they are in a strong minority. However, although not proof of causation, it is a useful tool provided it is used in conjunction with data obtained from the study of, in this case, individual stations.

The table shows that there is a high degree of correlation between all variables within the matrix. It is thus not possible to state categorically whether a particular ordination axis represents the effect of a single environmental variable. It will be seen that all ordination axes are positively correlated with mean grain size, though its relationship with Axis 1 is weak. Other results support some of the conclusions drawn in earlier sections. A good measure of the dispersal of sludge after dumping is the distribution of tomato pips. This is not ideal because these settle out much earlier than the finer sludge particles (Shelton, 1971). The table shows a correlation between tomato pips and Axis 1, which further suggests that this axis may approximate to the path taken by the settling sludge. There was no such correlation (which would have to have been negative since the zero score was at the dump site) between Axis 3 and tomato pips, but there was a strong negative correlation between this axis and per cent volume of fines (silt/clay). As stated, this axis originated at the dredge spoil dumping site, and could represent the path of this fine material. The correlation between Axis 1 and per cent volume of fines supports the evidence from the correlation with tomato pips, since sludge as well as dredge spoil contributes towards the mud in the sediment. These conclusions are, however, tentative, because the correlation procedure does not eliminate possible effects on the ordination axes of other variables besides the organic waste indicators.

Grouping of species

An advantage of the reciprocal averaging method is that it gives species as well as station ordinations. However, the final position of a particular species on any axis gives no indication of how widely that species is distributed. Thus a species occurring once will usually have a similar score as the station where it occurs. If it occurs in several stations, this score will only indicate the 'centre of gravity' of the species, not its spread. Here, the distribution of 80 species will be investigated in relation to their distribution throughout the three groups.

Species ordinations on the first three axes are shown in Fig. 8 (annelids) and Fig. 9 (non-annelids). For each figure the positions of 40 species are shown. Species were selected for inclusion in the figures from a total of over 300 for four main reasons. First, they were selected if they were common or widespread in Dublin Bay. Secondly, most species known to be characteristic of communities or indicative of pollution were included. Thirdly, several species of large size were selected, e.g. ophiuroids and *Nephtys* spp. Finally, species of geographical interest were also included.

The three dimensional diagram for annelids is shown in Fig. 8. Species occurring in the area on the diagram equivalent to that occupied by Group I stations include:

Sthenelais limicola	*Myriochele* sp.	*Sigalion mathildae*
Capitella capitata	*Prionospio malmgreni*	*Magelona mirabilis* (cf. *papillicornis*)
Nephtys hombergii	*Eumida sanguinea*	
Spiophanes bombyx	*Chaetozone setosa*	

Species in the Group II area in the diagram include:

Cirratulus filiformis	*Scalibregma inflatum*	*Notomastus latericeus*
Nephtys ciliata	*Gyptis capensis*	*Ampharete acutifrons*
Cirratulus cirratus	*Pholoë minuta*	*Spio filicornis*
Peloscolex benedeni	*Sthenelais boa*	*Scoloplos armiger*
Cirriformia tentaculata	*Nereis* spp.*	*Lanice conchilega*
Eusyllis blomstrandi	*Nephtys caeca*	*Pectinaria auricoma*
Mediomastus fragilis	*Phyllodoce* spp.**	*Lumbrineris gracilis*
Caulleriella (*Heterocirrus*) *alata*	*Owenia fusiformis*	*Pectinaria koreni*

**N. pelagica* with *N. longissima*
***P. mucosa* with *P. maculata*

On the borderline between Groups I and II is *Caesicirrus neglectus*. Species in the area of Group III include:

Microphthalmus similis	*Polycirrus* sp.	*Nephtys longosetosa*
Ophelia borealis	*Nephtys cirrosa*	

The diagram for non-annelid species is shown in Fig. 9. Group I species include:

Nucula tenuis	*Venus striatula*	*Ampelisca typica*
Phoronis mülleri	*Ophiura albida*	*Bathyporeia tenuipes*
Cultellus pellucidus	*Acrocnida brachiata*	*Tellina fabula*
Thyasira flexuosa	*Ampelisca brevicornis*	*Nucula turgida*
Ophiura sp. (small)*	*Gari fervensis*	*Ophiura texturata*
Dosinia sp.		

Species placed in Group II were:

Venerupis pullastra	*Mya arenaria*	*Tubulanus polymorphus*
Amphipholis squamata	*Cerianthus lloydi*	*Mysella bidentata*
Ampelisca diadema/tenuicornis	*Sagartia troglodytes*	*Ophiothrix fragilis*
Asterias rubens	*Photis longicaudata*	*Lucinoma borealis*
Erichthonius brasiliensis	*Ampelisca spinipes*	*Abra alba*
Photis pollex	*Nucula nucleus*	*Urothoë elegans*

In Group III are:

Echinocardium flavescens	*Spisula elliptica*	*Bathyporeia elegans*
Echinocardium cordatum	*Abra prismatica*	

On the borderline between Groups II and III is *Abra tenuis*.

The results parallel those obtained from the classificatory procedure (Tables 2, 3 and 4). However, it must be remembered that the majority of the species identified in this study were not included in Figs. 8 and 9 (see Appendix for complete list of species and their distribution).

CONCLUSIONS FROM NUMERICAL ANALYSES

The distribution of the benthic macrofauna in Dublin Bay resembles that in many other north-west European seas, although the communities are atypical when compared with the classical pattern (Petersen, 1918). The groupings do, however, fit in with Caspers' (1950) and Glémarec's (1973) systems. Classificatory and ordination techniques gave broadly similar community groupings, thus substantiating each other. Those stations most likely to be influenced by the dumping were distinguished (cf. Rees and Walker, in press). The benthos at the sludge-dumping site in 1971 showed some signs of modification, with a super-abundance of the polychaete *Cirratulus filiformis*. In 1972 there was here a return to a faunal situation resembling that of the surrounding area. Reciprocal averaging appears to separate the effects of dredge spoil from sewage sludge, deriving separate axes for each. Furthermore, this method has demonstrated a possible effect due to the Liffey estuary. These effects are reflected here solely as trends in the fauna; no additional environmental information has been called upon to influence the results.

VARIATION IN THE FAUNA BETWEEN YEARS

The abundance of the more important species was compared at 13 stations which were sampled both in 1971 and 1972. In particular a check was made to assess whether the repeat samples belonged to the same community group. An additional nine stations investigated in 1972 were new. They extend the area studied to the north of the sludge disposal site, to the east of Burford Bank, and into Dun Laoghaire Harbour.

Figs. 2 and 3 show that all of the repeat stations except 2D4 were included in the same groups as their 1971 equivalents. However, it will be seen that some of the indices (Table 8) between similarly sited stations from different years are low, and when samples taken from the same stations in both years are compared in more detail some differences are found. Changes in individual species are difficult to interpret. Most obvious was the great fall in numbers of *Abra alba* except at J14, and the absence of *Cirratulus filiformis* at A14, in

*see Appendix.

1972. To some extent the decline in *Abra* was balanced by an increase in *Tellina fabula*. Other noteworthy increases were *Lanice conchilega*, *Myriochele* sp., *Nucula turgida*, *Mysella bidentata* and *Ophiothrix fragilis*. Conversely there were falls (at more than one station) in *Prionspio malmgreni* and *Polycirrus* sp. It cannot be said for certain that the changes (including the reduction in *Cirratulus*) were due to any factor in particular. Some may reflect natural spatfall fluctuations or patchy distributions, but the switch from *Abra alba* to *Tellina fabula* may have been due to changes in the mud content of sediments after dredge spoil dumping had ceased.

To judge from the range of invertebrates listed by Massy (1912) as having been trawled in Dublin Bay there is no evidence of any change in the fauna since the early part of this century. Only three of Massy's tows were actually in the sampling area, and trawls inevitably pick up a different fraction of the total fauna than grabs. Many of the annelid species found by Southern (1910) and Abdel-Moez (1957), and maldanid polychaetes described by Arwidsson (1911), were also found in the present survey. In addition, results from the examinations of samples from boring by Naylor (1965) suggests little or no change in at least the molluscan fauna since early post-glacial times. However, while these conclusions may hold for the greater part of the bay, the absence of bottom-type notations showing mud in the outer parts of the bay on the Admiralty Chart based on a survey in 1874 suggests changes since that date, from a sand or shell community to one inhabiting the present more muddy sediments presumably caused by settling sludge and spoil. It is impossible to say whether or not many sensitive species have been driven out.

ADDITIONAL DATA FROM INCOMPLETELY IDENTIFIED SAMPLES (1972)

As it takes a long time to identify fully all the individuals in most samples not every sample was worked up in the second year. These samples were either examined cursorily at sea or in the laboratory. Prominent or easily identified species were noted. The results are shown in Table 9. Most of the duplicated stations appear to have faunas appropriate to the group in which their 1971 equivalents were placed. The presence of *Ophelia* in 2B14 indicated a probable shift from Group II to III; however, the edge of the Burford Bank is very close to this station. In many cases it is not possible to assign a particular station in this table to any one of the faunal groups discussed above. This is due to identification being in many cases at the generic level only. However, the results do suggest a general lack of change since 1971, and help to show the northern extent of the waste-affected area.

The northern boundary of Group II seemed in 1972 to lie between 2V15 and 2U15 (Group III). Faunal inspection data from the line 2U14 to 2Z14 showed that all except 2U14 (which contained *Ophelia*) probably had fauna typical of Group II. Since 2V12 was placed in Group II no conclusion is possible concerning the north-western limit of this group. It may indicate an area with a Group II fauna off the northern corner of Howth Head. On the 15 line, 2W15 is impossible to place, whereas 2Y15 is representative of stations in Group II. Of the stations on the 16 coordinate none can definitely be assigned to Group II. The presence of *Tellina fabula* and *Magelona* suggests that they were not affected by waste disposal. This confirms that the waste-affected stations generally lie up and down the tide from the dumping sites.

SAMPLE STRUCTURE AND DIVERSITY

QUANTITY OF MACROFAUNA

The numbers of species per station and individuals per m² are shown in Figs. 10 and 11, and in Table 10. There is a great similarity between the distribution of stations with high numbers of species and high numbers of individuals in 1971. High faunal density occurred in the region of the sludge dumping site, and the highest densities of individuals were at Z14 and A14 (1971), due to the large numbers of *Cirratulus filiformis* referred to previously. There was also a finger of high density extending into the bay from the south-east where sludge probably also settled at low water (Rees and Walker, in press). A region of low density was found near the middle of the bay on both the species and individual maps. Mean densities for species and individuals in each of the community groups were calculated (Table 1). High values were found for Group II.

DIVERSITY

Diversity indices may differ in their dependence on sample size (Sanders, 1968; Gray, 1974); also where dominance of equitability are considered in the calculation the end result will be affected. It was here necessary to use indices whose values were quickly available. Besides having this property the following two indices, the one a species diversity the other a dominance diversity (Whittaker, 1965; Sanders, 1968), can give useful definitions of sample population structures.

The species diversity (i.e. not accounting for equitability) used here is the α of Fisher *et al.*, 1943 (see Williams, 1947; also Sanders, 1968; Southwood, 1966; Stirn, 1970). Due to possible theoretical objections to this (and other indices) (Gray, 1974), the results must be viewed with caution. The results are more valid where the data fit logarithmic series. The formula is:

$$S = \alpha \log_e \left(1 + \frac{N}{\alpha}\right) \qquad \begin{array}{l} S = \text{number of species} \\ N = \text{number of individuals} \end{array}$$

In this case the results were in fact read off a nomograph plot, approximately.

The dominance diversity (accounting for equitability) utilized here is Hill's (1973b) diversity. This index is derived from Simpson's (1949) diversity and is calculated in the reciprocal averaging computer programme (see above). It ($N_{(2)}$) is defined as:

$$N_{(2)} = \frac{(S_1 + S_2 + S_3 + \cdots S_P)^2}{S_1^2 + S_2^2 + S_3^2 + \cdots S_P^2}$$

where S_p is the actual abundance of the p^{th} species.

This is the weighted arithmetic mean of the proportional abundances, and is not unduly affected by sample size (Eagle, 1974).

The two indices of diversity are mapped for the 1971 stations in Figs. 12 and 13, and are listed for the 1972 stations in Table 10. Samples of one lowering of the grab were not included in the column for Hill's diversity in Table 10 because the figures for these are based on samples doubled for the reciprocal averaging programme. The two maps of diversity are to some extent similar. High values tended to occur at stations in the region of the sludge disposal site (community Group II, see Table 1), except at Z14 and A14 (especially Hill's diversity), which are the 1971 stations closest to where most of the sludge probably settled. Values were also high to the south of the Burford Bank. Low values for both diversity indices were found on the northern part of the Burford Bank, in the middle of the bay, at the mouth of the river, and at the dredge spoil disposal site. In both diagrams a band of moderate diversity extends from the north of Dun Laoghaire Harbour towards the north and west.

In situations seriously affected by organic wastes the diversity index may be lowered both by a superabundance of a few species as well as by the actual elimination of other species. At lower levels of organic input it is possible that the number of individuals of some species can increase without any marked loss of other species (Rees *et al.*, 1972). Dominance may be high. This situation will also lower the diversity. At only moderate levels of organic input the environment is also capable of supporting abundant living matter but this may lead to an increase in diversity. These latter two levels of organic input both give rise to faunal enrichment. In such cases the diversification of the microhabitat may be an additional important factor (Gray, 1974 and 1976). Diversity may also increase naturally with depth (e.g. see Rees *et al.*, 1972).

Exceptionally high single species dominance occurred at Z14 and A14 in 1971 (but not 1972) which probably indicates enrichment. This high dominance was brought out by the very low values of Hill's diversity for these stations (Fig. 13). In this instance there was barely any associated elimination of other species (Fig. 10). The low diversity at B12 may be correlated with the dumping of dredge spoil in that area. This practice ceased in 1972, and the diversities and faunal densities there were then higher (Table 10). The low diversity areas in the middle of the bay and at the mouth of the river correspond approximately to the relatively barren areas on the maps of the numbers of species and individuals. These were areas with low percentage volume of fines, suggesting frequent winnowing of the bed, though at the mouth of the river this winnowing may have been masked by continual replenishment of fines. Differences in sampling months (May and July) in 1971, and/or a choppy sea during the May cruise, may have also accounted for the comparative paucity of these samples to some extent; but compare the 1972 results (Table 10). These were from three adjacent days in good weather. The oval-shaped area to the south of the bay in Fig. 13 with very low Hill's diversity is less easily explained in environmental terms.

Use of diversity in this study has tended to confirm conclusions already drawn about the benthos of the bay, although some of the individual trends in the diagrams are perhaps difficult to comprehend (especially for Hill's diversity). This may reflect short-comings in the interpreters rather than the concept. Nevertheless, it is suggested that detailed conclusions regarding diversity results should always be viewed in conjunction with other approaches (see also Pearson, 1975; Pearson and Rosenberg, 1976; Gray, 1976; Rosenberg, 1977).

CORRELATIONS BETWEEN FAUNAL AND ENVIRONMENTAL VARIABLES

The results from the correlation procedure (Table 7) show that depth, distance from the Liffey, per cent volume of fines (silt/clay), poorly sorted sediment, and tomato pips, which are all variables associated with the dump sites, are positively correlated with numbers of species and individuals. Numbers of species and individuals are positively correlated with ordination Axis 1 (a possible sludge gradient) and negatively correlated with Axis 3 (a possible negative dredge spoil gradient). Axis 1 is also positively correlated with α diversity. Numbers of individuals are poorly negatively correlated with mean grain size. Interestingly both types of diversity are positively correlated with mean grain size, and this is the only environmental variable correlated with Hill's diversity. It is of note that this, a dominance diversity, is correlated with less environmental variables than is α diversity, a species diversity (which is positively correlated with all environmental variables except per cent volume of fines and loss on ignition, but including tomato pips). This parallels the findings of Sanders (1968), who found species diversity to be a conservative and, therefore, ecologically powerful tool. It is possible dominance diversity is too precise in its definition of sample structure, and is thus more sensitive to random effects. Additionally, the very low Hill's diversities at the sludge dumping site (1971) might invalidate some potential correlations. (It should be noted that a few of our αs are not significant).

These correlation results suggest that the dumping is enriching and/or even possibly diversifying the habitat, though possible effects of the other factors also apparently correlated with this increase in the fauna must not be ruled out. However, this faunal richness certainly seems to be associated with the suggested path of the settling particles.

CONCLUSION

Low diversities occurred at the disposal sites (1971), but high densities and diversities were found in the probable dispersal path of the settling sludge. These high values may be due to niche heterogeneity, which itself could be partly natural or have been increased directly by the sludge particles. Higher density populations supported by the additional detritus could also biotically diversify the environment, or the intermittent input of fresh detritus could "open" the community for fresh colonists. All these factors may or may not operate together.

INDICATOR SPECIES

Studies of severely polluted areas have shown a series of concentric zones around the pollution source (Pérès and Bellan, 1970). In the worst cases there is a central zone virtually devoid of macrobenthic life. Outside this zone is a transitional zone where a few highly resistant transgressive species occur. They may be abnormally abundant. A third zone outside contains a wider range of transgressive and resistant species. Transgressive (Tulkki, 1968) or indicator species are essentially indicators of organic enrichment, rather than actual pollution (M. Parker, pers. comm.). Their life histories tend to display ecological opportunism and some may also be poor biological competitors, being less specialized to particular habitats (Grassle, 1972). The presence of such species, especially singly or sparsely, is not alone conclusive evidence of artificial enrichment or pollution (see Eagle and Rees, 1973); rather their abundance may indicate the effect of a particular pollution source. Such species existed before the impact of urbanization and the resulting effect on the natural environment, and were probably preadapted to man's coming in habitats that were naturally enriched and sometimes unpredictable (see Grassle, 1972). Such habitats sustained the evolution of adaptations such as wide physiological tolerance and flexibility of genotype (cf. Hunter, 1961), and still exist in the natural state. When indicator species are found during a pollution survey, it is therefore additionally useful to take into account their respective abundances and the structure of the communities to which they belong, and to consider the distribution of such species and communities in relation to the dispersal of potential pollutants. Possible sources of *natural* enrichment must not be overlooked.

DISTRIBUTION OF KNOWN POLLUTION INDICATOR SPECIES IN RELATION TO SLUDGE SETTLEMENT

All the species placed by the ordination procedure in the Group II area in the diagrams (Figs. 8 and 9) inhabited stations where the sludge probably settles, and are very likely transgressive. Many have been regarded as pollution indicators, which may confirm the suggestion that the habitat was being enriched. Most of the species in the other two groups are more likely to be less resistant, or regressive, though with exceptions.

Of the previously known transgressive species in Dublin Bay, *Capitella capitata* has been regarded as the most consistent indicator of marine organic pollution (e.g. Reish, 1970), and indeed, together with *Malacoceros (Scolelepis) fuliginosus* (e.g. Pérès and Bellan, 1970) it was found in high densities in the Liffey Estuary. However, recently doubt has been thrown on the reliability of *Capitella* as a *consistent* organic pollution indicator (Eagle and Rees, 1973); indeed Southward (1957) found it in clean sand. Work by Grassle and Grassle (1976) in U.S.A. shows that *Capitella capitata* in fact consists of at least six sibling species. These differ only slightly in their morphological characteristics, but their life histories and reproductive modes are very different, with wide variation in egg size, number in the brood, and length of larval life. *Capitella* was found to be quite common in Dublin Bay, but at no very great density, in a wide variety of substrates from fairly clean sand to mud. The species ordination procedure placed it in the Group I area on the diagram (Fig. 8), and so its presence in the bay is not necessarily related to pollution. However, another capitellid, *Mediomastus fragilis* Rasmussen (1973), was abundant in the area of probable sludge settlement.

Two species which were dominant in the area of the Dublin Bay dumping sites in 1971 were *Cirratulus filiformis* and, to a lesser extent, *Peloscolex benedeni*. Both these species have previously been found associated with polluted systems (Mackay *et al.*, 1972; Pearson, 1972). In 1971 *Cirratulus* occurred in densities of about 7,400 and about 10,400/m² respectively at stations Z14 and A14. However, these high densities were very local when compared with the probable dispersal of the sludge. Loss on ignition was not measured in 1971. In 1972 it was found that sediment from A14 had the highest percent loss on ignition, but not a single specimen of *Cirratulus* was found in the sample that year, so no direct conclusion is possible with regard to the effect of organic content on this species. In 1971 *Peloscolex benedeni* was found in considerable densities at B12 (620/m²), C12 (585/m²), and to a lesser extent, D12 (295/m²), and this may have been associated with the dumping of dredge spoil. However, many were also found at B12 in 1972 (335/m²). Thus once again no direct conclusion is possible, and we are left with two alternatives. Either those present in 1972 were the remains of a population once supported by the deposition of river dredgings, that will eventually die out, or *Peloscolex* lived there irrespective of the dumping of dredge spoil. Annual monitoring would clarify this point. The other *Cirratulus* species, *C. cirratus*, was present at low densities in the bay (cf. Mackay *et al.*, 1972).

The presence of *Pectinaria koreni* is of interest. Its absence off the Rhine has been attributed to pollution (Eisma, 1966), and it was also considered that the absence of a related species in California was an indicator of pollution (Reish, 1959). However, on the east coast of North America, a species of *Pectinaria* has been found to benefit by organic enrichment (McNulty, 1961). In Dublin Bay it occurred in over 50% of the stations of Group II (Table 3), yet at no great maximum density (30/m²). Its occurrence elsewhere in the bay was sparse, and it certainly seemed more common in regions of greatest percent volume of fines. Its presence *may* be correlated with enrichment (see Wass, 1967; Rees *et al.*, 1972), but not excessive pollution.

Other polychaete species that have previously been found to be associated with organic pollutants are *Pholoë minuta*, some phyllodocid species and *Lanice conchilega* (Pearson, 1975); *Scalibregma inflatum* and *Ampharete acutifrons* (Rees *et al.*, 1972); *Scoloplos armiger* (Blegvad, 1932; but see Anger, 1975a); *Prionospio malmgreni* and *Spiophanes bombyx* (Pearce, 1970); and *Nephtys hombergii* (Pearson, 1975; Rosenberg, 1977). These were common in Dublin Bay, and except for the last three species more prominent in Group II (Fig. 8). *Prionospio, Spiophanes* and *Nephtys hombergii* were more common in Group I, and in this case prefer not too close a proximity to the pollutant source as was found by previous authors. Another *Nephtys* species, *N. ciliata*, however was found in the Dublin Bay centres of apparent enrichment. Four further polychaetes in Dublin Bay, and previously found to be indicator species, were *Dorvillea* (= *Protodorvillea*) *kefersteini* (Pearson, 1975), *Cirriformia* (= *Audouinia tentaculata*) (Pearson, 1972; Pérès and Bellan, 1970), *Polydora caulleryi* (R. Shelton, pers. comm.), and *Pseudopolydora pulchra* (Crisp *et al.*, 1974; Seymour, 1976). These were not generally abundant.

Finally, mention must be made of *Eunice harassii*. As far as is known this species has not before been considered to benefit particularly from an organically enriched environment. Two specimens were obtained in each year, at A14 and A15 (1971), and at A14 (1972, in extra grab lowerings). In all four specimens the maximum number of gill filaments was far greater than the figure in the literature (Saint-Joseph, 1888), and in three of these it was greater than other specimens examined subsequently. It was found that there was a good linear relationship between maximum gill filament number and setiger width (Walker, 1977). The conclusion was that the Dublin Bay specimens were exceptionally large. Such size is very likely to depend on the amount of food available, and the dumping of sewage sludge in the area is probably responsible even if *Eunice* does not actually eat it.

The second important taxonomic group containing indicator species are the bivalve molluscs. *Abra alba* was considered by Stirn (1970) and Eisma (1966) to be an indicator of pollution, but Mackay *et al.* (1972) found it to be more typical of unpolluted areas. In Dublin Bay it was found to be almost ubiquitous, often in high densities (e.g. 3225/m²), which seem to indicate enrichment of the habitat. Other bivalves which probably benefit from enrichment are *Mya arenaria* (Blegvad, 1932; Henriksson, 1967; and Tulkki, 1968); *Lucinoma* (= *Phacoides*) *borealis* (Halcrow *et al.*, 1973), *Thyasira flexuosa* and *Corbula gibba* (Leppäkoski, 1968; Pearson, 1971b, 1972), *Mysella bidentata* (Rees *et al.*, 1972) and *Nucula turgida* (= *nitida*) (Tulkki, 1968). Of these *Mya* and *Lucinoma* were widespread in, and just about exclusive to, Group II (Table 5, Fig. 9). *Mysella* and *Thyasira* were widespread in Groups I and II, while *Corbula* was uncommon, occurring in Groups I and III. *Nucula turgida* was very common in Group I, but less so in II, where it tended to be replaced by *N. nucleus*. This was dense in places (e.g. 1115/m²).

Of the indicator species belonging to other taxonomic groups, *Cerianthus lloydi* (Mackay et al., 1972; Rees

et al., 1972) was an important constituent of Group II. Also belonging to this group were *Balanus crenatus* (Persoone and de Pauw, 1968) and *Erichthonius brasiliensis* (Barnard, 1958). *Phoronis mülleri* was widespread in the bay generally, whilst *Philine aperta* occurred in Group I, uncommonly (see Rosenberg, 1977).

CONCLUSION

In Dublin Bay the majority of the known indicator species belonged to Group II stations. They therefore inhabited substrates in the paths of the settling sludge and dredge spoil (see Rees and Walker, in press). The abundance of certain of these species suggested that their habitat was being enriched by the dumping.

The possibility of concentric zonation around the organic waste sources in the Dublin Bay area has been distorted by their proximity to each other, topography, prevailing currents, and the distribution of sediment types. It appeared that the azoic zone of Pérès and Bellan (1970) was absent (except several kilometres up the estuary). The transitional zone of large numbers of a few highly resistant species was not fully developed, though in 1971 Z14 and A14 (with very high numbers of *Cirratulus filiformis*) approached this state. The third zone was probably represented by the other stations in Group II. Groups I and III showed less evidence of the effects of potential pollutants.

FEEDING HABIT DIVISION

ISOTROPHIC GROUPS (FEEDING TYPES)

The variety of feeding methods exhibited by benthic animals reflects the numerous and diverse taxonomic groups to be found on the sea floor. Some forms seek out their food, others wait for it to arrive, whilst yet others direct food towards themselves. Soft-bodied animals may have searching ciliated extendible palps, expansive collecting surfaces also maybe with cilia, or eversible stomachs or probosces. Jaws or teeth of various sorts may be present. More rigidly built species may have an array of differing appendages that grasp the food or which operate as levers or paddles to help ingest it.

In spite of their many ways of obtaining food, most benthic animals (apart from some carnivores and parasites) show little specialisation in their diets. In this study species were placed in one or more of four isotrophic groups, *i.e.* assemblages of species with similar food. These groups are: deposit swallowers, microvores, carnivores-scavengers, and herbivores.

1. *Deposit swallowers.* These animals are sediment eaters and ingest the sediment *in toto*, though small species may be unable to swallow the larger particles. Their gut contents generally resemble the surrounding sediment (apart from gut bacteria). They feed mainly unselectively; however, during larval or adult life many of them choose a particular sediment in which to live.

2. *Microvores.* This group, which may also be termed detritus eaters (see Eagle and Hardiman, 1977), is a combination of the more usual surface-deposit feeders (some may in fact be sub-surface feeders) and suspension feeders (e.g. Pearson, 1971a). These species usually feed on organic remains and/or very small organisms, and are generally selective in their methods. The gut contents of these animals contain a higher fraction of organic matter than does the surrounding sediment.

Although the erection of the large composite group microvores results in the loss of information, it was considered appropriate here for two reasons. First, under certain conditions the distinction between surface-deposit feeders and suspension feeders may become blurred. A surface-deposit feeder is normally thought of as feeding on stationary particles situated on (or just in) the sea bed. Conversely, a suspension feeder takes particles that are moving, and are in the water above the sea bed. However, there is the intermediate situation, when food particles sink to the sea bed, but still move with the currents and waves. This material, mostly detritus, may become entangled in the feeding mechanisms of both surface-deposit and suspension feeders, or may become stationary at slack water to form the food of surface-deposit feeders.

The second (and more important) reason for combining surface-deposit with suspension feeders is that the precise feeding methods of many microvores are unknown, e.g. long-palped polychaetes. Many of these are usually considered to be surface-deposit feeders, e.g. *Chaetozone, Spiophanes*, but some may well be at least partial suspension feeders (D. George, pers. comm.). Both these two species, together with some other 'doubtful' surface-deposit feeders, were found to be common in Dublin Bay, and in such cases it is better to avoid errors than to attempt greater precision of definition.

3. *Carnivores-scavengers.* These species feed on animal matter whether dead or alive, and whether living on or in the sea bed, or swimming above it. Their food is generally larger than the sediment particles, except in some cases when the carnivores are themselves small.

4. *Herbivores.* These animals feed on plant material, which in this case probably consists of films or mats on stones or on the sea bed. They are epistratum feeders.

To some extent these categories are unsatisfactory as Groups 1 to 3 are in ascending order of selective specialisation. But in this way selectivity is itself examined. Secondly, the definitions of the first two groups are not absolute with regard to diet, and relate to the properties of the sediment. A deposit swallower in an organic sediment may have proportionally as much organic matter in its gut as a microvore (surface-deposit feeder) in a less organic sediment. It is also realized that there may be overlap between the groups. The feeding habits and diets of the various species were found from the literature and from specialists (Table 11).

Many species adopt more than one type of diet, and such animals have been placed in more than one category. For instance, *Ophiothrix fragilis* may be carnivorous, or it may feed on detritus (either as a suspension or surface-deposit feeder). Many species classified in other categories may at times be carnivorous, ingesting settling spat or meiofauna (Kristensen, 1957; Mare, 1942; Sanders *et al.* 1962; Thorson, 1966).

Finally, it is being found that several marine organisms make use of dissolved organic matter as a source of nutrition (Southward and Southward, 1972; Stephens, 1968, 1975; West *et al.*, 1977). The full importance of this phenomenon in the natural situation is little known at present, and hence it is not considered here in the numerical analysis. It may be very important to some species, especially in an area receiving much dissolved as well as particulate organic matter.

DOUBTFUL FEEDING HABITS

The feeding habits and diets of certain species have caused disagreement between some workers, while those of yet other species have not been studied at all. Some of the above authors cover different species from those of the same genus found in Dublin Bay, whereas the actual species of that genus found in this study may not have been investigated. While occasionally different species of the same genus have different feeding habits, here all species in a particular genus were considered to have broadly similar diets unless there was evidence to the contrary. Congeneric benthic species do not generally differ in their diets, and differences in other factors such as distribution would seem to be more important in reducing competition between closely related species on the sea floor.

The anthozoans are a group where there seems to be controversey, and the smaller sea anemones were all here considered as microvores/carnivores. While the classical viewpoint holds that most of these are exclusively carnivorous, feeding on large prey, there is the possibility that they may also take particulate food items (Buhr and Winter, 1977; Rhoads, 1974).

There are several other cases where authors disagree on the methods of feeding of particular genera or species. This is the case for certain of the errant polychaetes. The classical viewpoint, proposed by many workers such as Blegvad (1914), Hunt (1925), and others, is that most of these worms are carnivorous. On the other hand Sanders (1956), Sanders *et al.* (1962) and Watling (1975) suggest that many such species are deposit feeders. Of these genera *Nephtys* has been studied most, and from the work of Clark (1962) and Warwick and Price (1975), it appears that, at least in European waters, these animals are carnivores and may sometimes be cannibalistic. This latter point is of interest as often samples contain little else apart from several *Nephtys* individuals. It is possible that large ones eat the smaller ones, which themselves feed on the meiofauna that is not sampled (i.e. is sieved out). Professor O. Vahl (pers. comm.) has observed *Nephtys* feeding on foraminiferans. The remains of foraminiferan shells in the gut might resemble sediment. It must be mentioned that the presence of sediment in an animal's gut is not proof that it is a sediment eater. It could be that the prey species are feeding on sediment which remains undigested in the predator's gut after the prey's tissue has been broken down (cf. Thomas and Davidson, 1962, page 6). However, the densities as well as the gut contents of Sanders' (1956) *Nephtys* specimens implied deposit feeding, a habit seemingly unusual for the genus (Clark, 1962).

Another group where there is uncertainty is the Syllidae (Day, 1967a). Most of these appear to be carnivorous, but it is possible that at least *Exogone* (Watling, 1975) and *Sphaerosyllis* may be microvores (surface-deposit feeders). Rasmussen (1973) states that *Exogone* feeds carnivorously in the plankton when breeding. A specimen of *Exogone* from our samples has, however, been found with diatomaceous material in the gut.

Lumbrineris is also a genus whose diets appear imperfectly known, different species of this genus may feed differently. Professor O. Vahl (pers. comm.) has observed them feeding carnivorously. Investigation of the gut contents of our specimens (*L. gracilis*) revealed a nematode in one, while the rest had empty guts. This confirms Professor Vahl's observations.

The diets of several hesionid polychaetes seem to be little known. Following Pearson (1971a), in this study most are considered microvores/carnivores, though some may be exclusively carnivorous (see also Wolff, 1973).

Oligochaetes, often considered deposit swallowers (Pearson, 1971a), may show some selectivity (Brinkhurst and Jamieson, 1971; Dr. B. Healy, pers. comm.) and are here considered deposit swallowers/microvores.

The chiton *Lepidopleurus* is normally considered to be a herbivorous scraper (Pearson, 1971a). However, the Dublin Bay specimen was found at 32 m depth, and, besides scraping algal films, it is likely to have ingested epifauna as well. It is therefore here considered a carnivore/herbivore.

Genera with apparently unknown feeding habits include *Pisione, Ephesia* (both polychaetes) and the amphiurid brittle star *Amphipholis*. *Pisione* may be a carnivore as its jaws appear suitable for seizing prey.* Investigation of the gut contents of *Ephesia* (there was only one) gave little hint of its diet. But there was no trace of sediment so it is here considered to be a microvore/carnivore. *Amphipholis* was also placed in this mixed category as it appears that ophiuroids feed on both detritus and animal matter (Thorson, 1971).

Each individual was assigned to as many isotrophic groups as were considered appropriate (Table 11), its score in each group being the reciprocal of the number of groups in which it was placed. Scores were produced for each station in four ways: for species, individuals, per cent species and per cent individuals. Mainly for logistic reasons biomass figures were not used, and all individuals were scored alike whatever their size. It will be realized that this method gives no information on productivity or energy flow. In addition, it must be remembered that the food web here is not complete, for neither protozoans, meiofauna, plankton or fish were sampled. Colonial species such as hydroids are also omitted. However, it is hoped to show here the exploitation of the available habitats by the main macrobenthic isotrophic groups, and any possible effects of the sludge reflected in high densities of particle feeders.

DISTRIBUTION OF FEEDING TYPES IN DUBLIN BAY

The feeding type scores for species and individuals (and also their percentages) for the community groups are shown in Tables 12 and 13 (omitting herbivores). It was found that at most stations microvores were a predominant isotrophic group. These, together with deposit swallowers were considered by Petersen and Boysen Jensen (1911) to be the producers of benthic ecosystems, feeding mainly on various forms of detritus (it will be noted that Lindeman, 1942, used this terminology in a different way). Particle feeders were especially abundant at the sludge dumping site in 1971. The consumers, the carnivores, were a minority group in Dublin Bay, as found by Mare (1942) in a muddy area near Plymouth. However, it must be remembered that many of the so-called producers may ingest animal food, whether deliberately or not (Kristensen, 1957; Thorson 1966).

While the differences in the abundances of the faunas of the three community groups (Table 1) are reflected in the numerical feeding type scores in Table 12, in percentage terms these differences are much reduced (Table 13). Significant relationships between the percentages and environmental variables that characterize the community groups do exist, and are brought out by the correlation procedure (see below). Nevertheless, the Group II area, which has the added detrital inputs, shows no gross distortion of the feeding divisions if all the percentages are viewed together, with microvores (including both surface-deposit feeders and suspension feeders) having high scores in all instances. The most divergent of the percentage scores for any one feeding group in the three community groups never differs from the nearest of the other two scores (in the other two community groups) for that same feeding group by more than eleven (Table 13).

Within the community groups the constant proportional composition of the samples is brought out by the low standard deviations of the percentage scores. Even the numerical scores show some constancy within the community groups. The only instance where the standard deviation is greater than the mean is the individuals score for deposit swallowers in community Group I.

The percentage results compare approximately with some of those of Anger (1975b) working in the south of Kiel Bay. His species to individuals percentage ratios for the sand bottom are 26:1 (predators) and 74:99 (particle feeders). The low percentage individuals score for carnivores may reflect a different level of pollution than was found generally in Dublin Bay. For community Group II the mean percentage individuals score for carnivores is somewhat higher (9.9), yet at a station at the sludge dumping site (A14, 1971) this score was 3.2. This was the lowest *percentage* individuals score for carnivores for all the stations sampled, yet at several stations the actual *numerical* score was lower than at A14.

INTERRELATIONSHIPS BETWEEN THE FEEDING SCORES AND OTHER STATION VARIABLES

The positive correlations (Table 7) of depth, distance from the Liffey, per cent volume of fines (silt/clay) and sorting coefficient with numbers of species and individuals of all feeding groups suggest that these are all benefited by the input of sludge and spoil, as it is in the dumping area where these environmental variables are

* Later observations showed that *Pisione* is in fact *herbivorous*. There were too few here to influence the results unduly (see Appendix).

Compare Fauchald, K. and Jumars, P. A. (1979) The diet of worms. *Oceanogr. Mar. Biol. Ann.Rev.* 17, 193-284.

greatest. There are also appropriate relationships between the numerical feeding type scores and ordination Axes 1 (a possible sludge gradient) and 3 (a possible negative dredge spoil gradient), which support this proposition. But it is not necessarily the nutrient properties of the sludge alone that may be beneficial, and a contributory variable may well be the higher sorting coefficient (indicative of poorly sorted sediment). The available stones, shells and cinders in these muddy areas form suitable substrates for epifaunal feeding types alongside the infauna present. Indeed as stated by Rees and Walker (in press), the topography and absence of mud notations on the 1874 Admiralty Chart suggests that the area to the east of Howth Head is a headland scour depression. Before sludge dumping the exposed stony area may have been greater and supported more epifauna. On the accretion of settled sludge some of these would have been replaced by infaunal representatives of the feeding groups especially deposit feeders.

The species scores for all feeding groups are positively correlated at various levels with tomato pips. This sludge indicator (Shelton, 1971) is also correlated with the individuals scores for microvores and carnivores, but not deposit swallowers. However, the only isotrophic group positively correlated (though weakly) with probably the best indicator of sludge settlement, loss on ignition (1972 only), is this latter group. No relationships were found between deposit swallowers or carnivores and mean grain size (except for percentage scores); however, there is a poor negative correlation between this variable and the numbers of individuals of microvores. Pearson (1971a) found a negative correlation between surface-deposit feeders and mean grain size.

While the correlation procedure shows these relationships of the numerical scores for the isotrophic groups, the method does not rule out the possibility of these increases in the groups being dependent solely on a factor such as depth (see above). The apparent relationship with the dumping could be coincidental, though this is unlikely. It is very probable that many of the particle feeders in the area feed directly on the sludge (see Anger, 1975b).

Although as stated there are broad similarities in the proportional isotrophic compositions of the three community groups, the correlation procedure reveals affinities within the data that may be indicative of meaningful differences in the effects of sludge and spoil on the isotrophic groups. The relationships between environmental variables and the *percentage* feeding scores show how particular variables are related to the balance between the three main isotrophic groups, with the combined scores at each station being reduced or increased to 100. Thus per cent volume of fines (silt/clay), although positively correlated with the numerical individuals score for carnivores, is negatively correlated with the equivalent percentage score. This shows that, although carnivorous individuals increased in number under muddy conditions, proportionally they did not do as well (with each station being given equal weight) as the other two groups, especially individuals of deposit swallowers (Table 7). Similar results were found with these isotrophic groups and poorly sorted sediment. Poorly sorted muddy sediment occurred in the Group II, waste affected area, and this may indicate that, while the dumping may have been benefiting all feeding types, proportionally it benefited the individuals of deposit swallowers the most and carnivorous individuals the least. More detailed conclusions may be derived from the correlations of ordination Axes 1 and 3 with the percentage scores, suggesting that species and individuals of (less selective) deposit swallowers benefited the most in the sludge settlement areas, while those of (selective) microvores benefited the least. From these results it is also possible that it was in the areas affected by dredge spoil that species of deposit swallowers and carnivorous individuals benefited the least. On the other hand, *species* of carnivores were proportionally superior to the other isotrophic groups in the regions of probable settlement (Table 7).

CONCLUSION

Microvores were generally a dominant isotrophic group at most stations throughout the sampling area, in terms of numbers of both species and individuals. There were high numbers of individuals of particle feeders (producers) at the sludge dumping site in 1971.

Most of the variables associated with the settlement areas were strongly positively correlated with increases in the numbers of species and individuals of all three main isotrophic groups, which suggests no gross environmental degradation. These results were confirmed by the relationships of ordination Axes 1 and 3 with the numerical scores. Thus the proportional compositions of the three community groups were broadly similar in terms of their isotrophic groups. In spite of this approximate similarity, the correlations of the dump sites variables and ordination Axes 1 and 3 with the percentages disclosed that proportionally the feeding groups were benefiting differentially from the dumping.

The probable effects of the fauna of increased depth, greater sediment heterogeneity and currents in the settlement areas must not be ignored, and may also favour higher numbers of all feeding types.

DISCUSSION

The upper regions of the Liffey estuary are noticeably affected by an excess of organic matter (Crisp *et al.*, 1974; Seymour, 1976). The zones of Pérès and Bellan (1970) were found in a 4 km section of the port to seaward of Butt Bridge in the city centre. The innermost zone characterized by black gaseous sediment was azoic. This was followed by a zone where few species in great abundance were dominant. These were *Capitella capitata, Scolelepis (Malacoceros) fuliginosa* and *Pseudopolydora pulchra*. The fauna became more normal further down the estuary towards the sea. The effects of the discharge plume from the estuary on the bed of the bay were detectable for only a short distance seaward of Poolbeg. The nature of the estuarine hydrography is such that most of the tidal mixing between brackish and fully saline waters occurs inside the breakwaters, and most of the particulate material is kept within the estuary basin. Total freshwater flow into the estuary basin, measured in April-May 1971, was on average equivalent to less than a thirtieth of the springs tidal volume (Owen, 1973). As the tide range is itself relatively small (3½ m.), and spates are prevented by the hydro-electric dam upstream, there is not much opportunity for material to be flushed out into the bay. However, possible subtle effects of the estuary may have been detected by reciprocal averaging.

The benthic fauna of most of the bay appeared normal for this type of area, and was fairly rich in both numbers of individuals and numbers of species. It resembled that found in many other shallow bays in north-west Europe where the sediment is medium to fine sand with a moderate admixture of mud, and consisted mainly of a mixed shallow *Venus/Abra* community, similar to the *Acrocnida brachiata/Clymene oerstedi* community of Glémarec (1969). On the sand-banks the sparser communities contained a mixed community with many species of Glémarec's *Ophelia borealis* facies of the *Venus fasciata* community. Off Howth Head in the primary sewage sludge dumping area and in the area where the dredge spoil from the estuary used to be dumped, the fauna resembled Caspers' (1950) *Nucula nucleus/Sabellaria spinulosa* community, yet showed signs of probable enrichment. Compared with the 1874 chart notations there seems to have been a moderate introduction of mud to the sediment. The benthic fauna in the area of sludge settlement generally had greater numbers of species and individuals than other stations, and a greater diversity (apart from at the actual dumping sites in 1971). This is probably due to enrichment, but it may also be partly associated with greater depth. The presence of mud in the probable scour depression to the east of Howth Head is likely to be attributable mainly to sludge dumping. Therefore it is likely that this area has evolved from a stony community towards one of muddier sediments.

Some of the species which were present in abnormal abundance are known indicator species which benefit from the addition of particulate organic matter to the environment. Their distribution suggested that the sludge was having an enriching effect. These species increased in number without any reduction in the range of species present; indeed, the addition of organic material may have artificially diversified the habitat. The effect of dumping could be detected in the fauna and sediments along a band up and down the tide from the dumping area, and along a finger directed into the bay from the south-east corner of the sampling area where the flood tide runs into the bay (Rees and Walker, in press). Data taken from two years sampling (1971 and 1972) showed few changes, suggesting that the communities were sufficiently diverse to retain stability.

Further work on pollution has been in progress in the eastern Irish Sea, involving the effects of sewage pollution in Liverpool Bay. There were two series of benthic investigation. One was concerned with the disposal at sea near the North-West Float of half a million tons (1970) to 1½ million tons (1976) annually of activated sludge from the Manchester area. During this study the effects of the Mersey plume containing sewage and other pollutants from Liverpool and Merseyside were also investigated. This work has continued since 1970, and the results for the benthic studies for that year, 1972 and 1973 have been written up respectively by Rees *et al.* (1972), Rees (1973), Rees and Walker (1976). The second series of investigations was by Eagle (1973, 1975) on the shallow water benthos in the extreme south-east of Liverpool Bay, and the effects of the installation of a new sewage outfall that discharged well below low water spring tides. Rees (1975) reviews the general distribution of benthic communities in Liverpool Bay.

Eagle found little effect from the outfall, yet his faunas were in a state of dynamic fluctuation. He found two main habitats, muddy sand dominated by either *Abra alba* or *Pectinaria koreni*, and clean sand occupied by a very sparse fauna. There were also intermediate and aberrant groups, but many species were common to all habitats. The alternation of species in the muddy sand habitat was brought about by sediment instability caused by the re-working feeding mechanisms of deposit feeders (Rhoads and Young, 1970). This was followed by the animals being washed out during storms. During periods of calm there was re-colonisation by the larvae present in the plankton at the time. The sandy habitat supported a sparse fauna which varied with silt content which again varied with the weather. There was accretion of fines when it was calm, and winnowing out during heavy wave action.

The series of studies of Liverpool Bay proper by Rees and his co-workers have found that the macrofauna fits broadly into the normal pattern of communities. The shallow *Venus* community in offshore sand graded into an *Abra* community at depths less than 15 m. Further offshore was found a deep *Venus* community in sandy gravel; and when there was more mud present, a muddy gravel community was found similar to that of Holme (1966), in the English Channel. This was the richest of the Liverpool Bay communities. It was found that the outflow of the River Mersey had a greater effect on the benthos than did the disposal of sewage sludge at the North-West Float. The muddy sands off the Mersey fall into the moderately polluted category, while in the immediate area of the disposal site tidal currents were strong enough to disperse the sludge. In general it was found that the intermittent mobility of the seabed was the most important factor determining the nature of the fauna, especially in the south of the bay where it is shallower and where the currents are stronger.

Two years after the initial study the conclusions were similar but the dominant species had changed (Rees, 1973), while in the next year, 1973 (Rees and Walker, 1976), very few individuals were found, but of a high number of species. Hence diversities were unusually high. This series of samples was taken after periods of stormy weather, and the unusual structure of the communities was almost certainly due to indiscriminate washing out during storms. In 1974 the situation had returned to normal (unpublished data).

Studies of the effects on the benthos of sludge dumping at sea in several other areas have been carried out. Jenkinson (1972) investigated the effects of sludge dumping from Southampton. Each winter 55,000 tons of sewage sludge are dumped in the Hurst Deep, and each year 22,500 tons are discharged in the Needles Spoil Ground. There were no obvious signs of deterioration of the benthic fauna at either site. The grounds were stony, and hence the species present were mainly of the rock epifaunal type. The fauna was normal, consisting of amphipods, nemertines, nematodes, echinoderms, coelenterates, etc., and bryozoan species such as *Epistomia* (= *Notamia*) bursaria, which was previously found there in the last century (Hincks, 1880). This species is rare or absent in all other British localities.

Shelton's (1971) study concerned the dumping in the Thames estuary (Barrow Deep) of five million tons of digested sewage sludge annually from London. He found generally full oxygen saturation at all times, but organic matter in the sediments was high in the mouth of the estuary and in the Black Deep. The fauna of the area contained numerous polychaetes some of which have been recorded as indicator species, but *Capitella capitata* and *Nereis succinea* were not found. Amphipods were numerous, but bivalves and echinoderms were infrequent. The fauna represented an *Abra* community and in general appeared relatively normal.

Mackay and Topping (1970), Mackay *et al.* (1972) and Halcrow *et al.* (1973) investigated the effects on the benthic fauna of the dumping annually of a million tons of variously treated sewage sludge in the Firth of Clyde. The main molluscan/echinoderm fauna gave way to a polychaete fauna in the sludge disposal region. The species present included *Cirratulus cirratus, C. filiformis, Capitella capitata, Scolelepis fuliginosa,* and *Peloscolex benedeni.* Less commonly were found *Cerianthus lloydi, Nereis zonata, Lumbrineris* sp., *Glycera capitata,* and *Phacoides* (*Lucinoma*) *borealis. C. lloydi,* together with *Pygospio elegans,* occupied mainly the periphery of the sludge area. Associated with more organic matter in the sediment there was also a greater biomass. In the peripheral unpolluted region prominent species were *Abra alba, Nucula tenuis* and *Amphiura chiajei,* and less commonly *Glycera alba, Goniada maculata, Nephtys incisa* and *Travisia* sp. Epifaunal species such as *Crangon allmani, Pandalus montagui* and *Buccinum undatum* were common in and around the sludge area.

Watling *et al.* (1974) studied the effects of the dumping of nearly 0.4 million tons of sewage sludge per year from 1961 to 1972 off the mouth of Delaware Bay, U.S.A. They found that the sludge was not settling directly on the site; there was an abundant fauna in and around the dumping ground, and where sludge might be settling. Prominent species by abundance and occurrence included *Nucula proxima, Ensis directus, Tellina agilis, Nephtys picta, Edotea montosa, Parahaustorius wigleyi, Trichophoxus epistomus* and *Cancer irroratus. Nucula* occurred in such high quantities that the authors likened its abundance to that of well-known indicator species elsewhere. High numbers of individuals (with or without *Nucula*) were significantly positively correlated with small particle size and high organic matter, where diversities tended to be low, with high dominance. Coarser sediments than those inhabited by *Nucula* tended to be dominated by *Ensis directus,* though no significant associations for this bivalve were found. No gross indications of lesions or tumours were found on any species. The authors concluded that the benthos was undergoing dominance changes due to the gradual accumulation of organic particles. Although these changes cannot clearly be attributed to sewage (see D.O.E., 1978), it is nevertheless not impossible that they may be, and that the sludge is the cause of the high densities of *Nucula proxima.* This species occurred on the periphery of the nearly azoic polluted area in the New York Bight (Pearce, 1970, see below). Species of deposit-feeding *Nucula* were also common to abundant in Dublin Bay, especially at the stations most affected by the sludge.

An extreme case of pollution due to sludge dumping in the New York Bight has been documented by Pearce (1970). The total annual quantity dumped, including dredge spoil and industrial wastes, was eight million tons in 1960-1963, and from 1964 to 1968, 9.6 million tons. Both sludge and dredge spoil dumping sites were devoid of normal benthic fauna, and together the affected areas encompassed 50 km². The organic matter in the sediment of the nearly azoic area tended to be above 10 per cent. The only animals that were occasionally found in these areas were single specimens of the amphipods *Unciola irrorata* and *Monoculodes edwardsii,* but these may have been carried to the area by water movements. Moribund and dead crabs, *Cancer irroratus,* were occasionally taken from the area. These often had eroded skeletons and gill chambers filled with sediment. This species was otherwise common in the New York Bight during its summer offshore migration. It was also found that the megalopa of this crab died after settling in the sludge area.

Peripheral to the sludge disposal area *Cerianthus americanus* (cf. Halcrow *et al.,* 1973) rhyncocoel worms (nemertines), several polychaete species, *Yoldia limatula* and *Nucula proxima* were found. The polychaete *Prionospio malmgreni* dominated some of these outer stations, while the lamellibranch *Tellina agilis* and other bivalves were found at other outlying stations. There was no close correlation between organic matter in the sediment and enrichment of the fauna.

The dredge spoil dumping ground was as badly affected as the sewage sludge dumping ground. The central area was azoic, and a limited fauna characterised by a few dominant bivalves including *Spisula solidissima* and *Tellina agilis* and dominant polychaetes including *Prionospio malmgreni* and *Spiophanes bombyx* surrounded it. The sand dollar *Echinarachnius parma* was also common on the periphery.

The quantity of material and the hydrographic conditions influencing dispersal are the main factors which determine the extent to which the benthic ecosystem is affected by a dumping operation. When small quantities are dumped into waters with strong tidal currents, incorporation into the general detrital trophic pathway is complete and no deleterious effects are detectable. This presumably happens off Southampton. In Liverpool Bay and in the Thames Estuary currents are also strong and the dumping grounds are in areas where the seabed sediments are mobile. In both cases any effects that might be seen after the sludge has dispersed from the immediate dumping grounds are obscured by the polluting loads carried by the industrialised estuaries. On the other hand the Clyde dumping ground off Garrock Head is in a naturally muddy area with small tidal currents, so there is much less dispersal from the dumping ground, and the effects are more clear cut. The effects of dumping off Delaware Bay are less distinct, though there is a biologically enriched fauna in the general area of the dump site. Off New York the magnitude of the dumping and the added dumping of toxic wastes has resulted in severe effects even though there are moderate currents. The terminology of Dr. A. D. McIntyre (D.o.E., 1978) is here useful, the grounds used by Southampton, Manchester and London being considered 'dispersing', and those used by Glasgow and New York to be 'accumulating'. Delaware Bay would appear to be intermediate, a situation also found at the Dublin site here.

In Dublin Bay the quantity of sludge is relatively low but the tidal currents are only strong enough for partial dispersal from the dumping ground. Unlike Liverpool Bay, where the dumping site has about the same depth of water, the Dublin locality is sheltered from the prevailing westerly weather by the land and from the east by offshore banks. Therefore the Dublin site naturally has a more stable seabed. It is also possible that in some circumstances the addition of sludge or dredge spoil will change the character of the seabed sufficiently to stabilize it. China clay waste may have had this effect off Cornwall (Portmann, 1970; Howell and Shelton, 1970).

In situations where sludge settles in some concentration there is liable to be a shift in the balance between the different trophic groups in the benthic ecosystem. In extreme conditions the entire 'productivity' of the system depends on the few superabundant species of deposit feeders such as *Capitella, Scolelepis* (*Malacoceros*) and, in this case, *Cirratulus.* Off Dublin, however, all feeding types appear to be benefiting from the sludge, and there are increases in carnivores as well as in the particle feeders. It is just possible that to some invertebrate carnivores sewage resembles animal matter, and they may eat it as may some normally carnivorous birds (Pounder, 1974).

Many benthic invertebrates are eaten by bottom-feeding fish, and most of these fish are suitable for human consumption. For many years now it has been an ambition of mankind to farm the fish of the sea (see e.g. Hardy, 1959). At the end of the last war experiments were tried in raising the productivity of some Scottish sea lochs using agricultural fertilizers (Raymont, 1949, 1950). Although this end was achieved, the economic and biological efficiency of the scheme did not merit continuation on a commercial scale. As pointed out by Holme (1953), too many invertebrate predators and competitors for nutrients resulted which reduced the efficiency of the system from a human point of view. More recently the cultivation of fish in ponds whose ecosystems have been fertilized by human sewage is being tried in more eastern countries (Allen, 1972). Sewage has the advantages over agricultural fertilizers that it requires little or no processing, and that a continuous supply is produced which has to be disposed of. The open sea can be an alternative to pond cultivation for a sewage-supported fishery, requiring little initial planning and no maintenance. A knowledge of the dispersing ability and directions of the currents would be required to prevent too great a concentration of solids on the sea bed, the fouling or bacterial contamination of beaches or shellfish, or hypertrophication. Too rapid a dispersal of the sludge would also be undesirable. Secondly the sludge would have to be relatively pure and free from toxic wastes such as heavy metals and other bio-accumulative materials to prevent situations reported by Mackay *et al.* (1972), Halcrow *et al.* (1973), Pearce (1970), and Young and Pearce (1975). Thirdly care would have to be taken that sensitive species such as *Nephrops* are not driven out (D.o.E., 1978). In general the dependence of the biosphere on the seas, landlocked and without the infinity often assumed (see Ward and Dubos, 1972), must be the priority consideration before contemplating dumping.

If, in view of a predicted continued rise in the human population, efficient use is to be made of the world's resources, it will probably be found that man is obliged to accept more immediate recycling of materials than is the custom at present. It is highly likely that sewage will have to be one of such materials, providing an important and, it is hoped, acceptable source of nutrients. Although discharge of sludge to the sea is now seen only as an economical means of disposing of it, this attitude needs to be re-examined. With modifications to dumping strategy it is possible that dumping for disposal could give way to dumping for beneficial enrichment.

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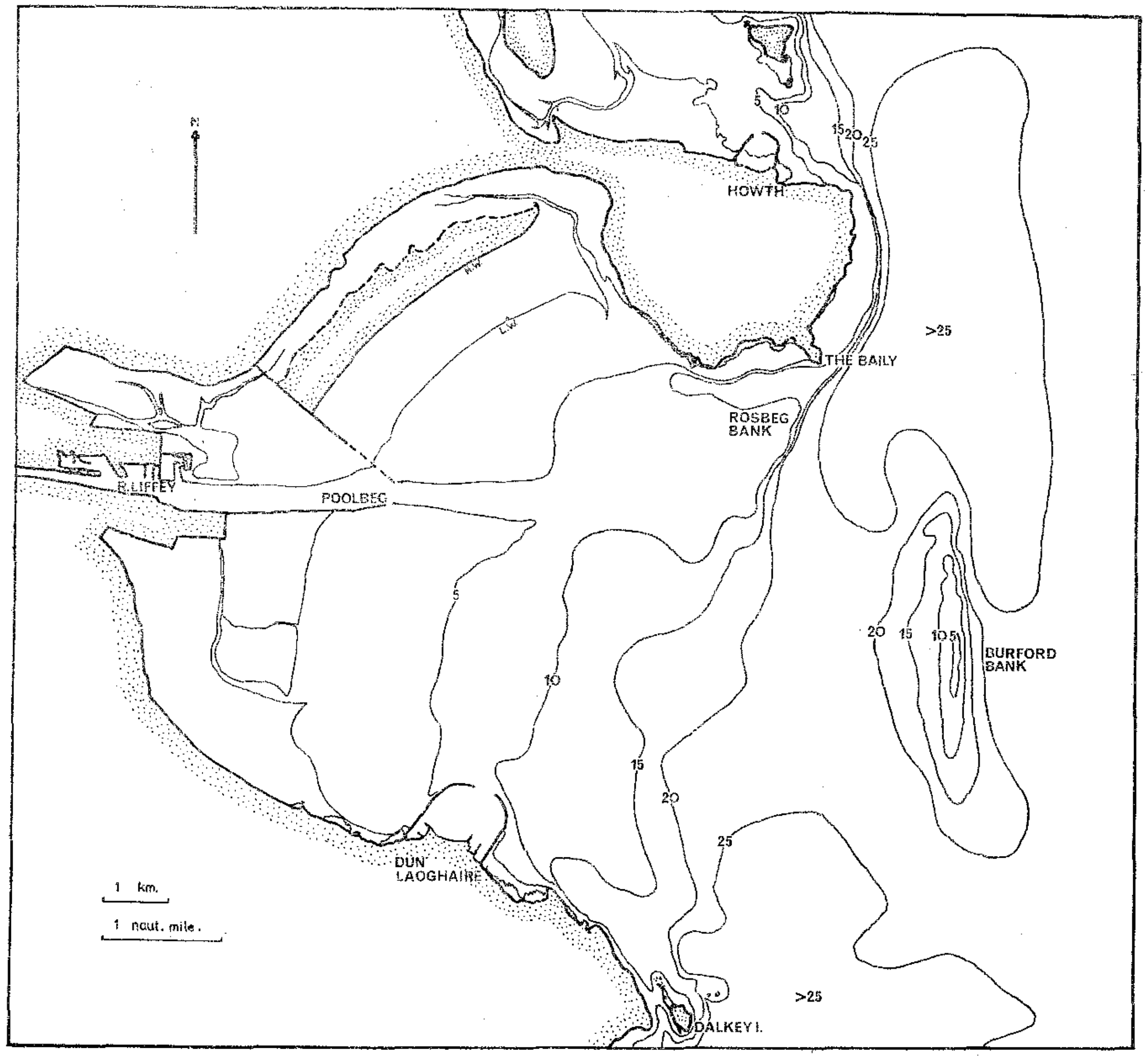

FIG. 1a. Dublin Bay. Depth contours in metres. Adapted from Admiralty Chart 1415 (corrected to 1969).

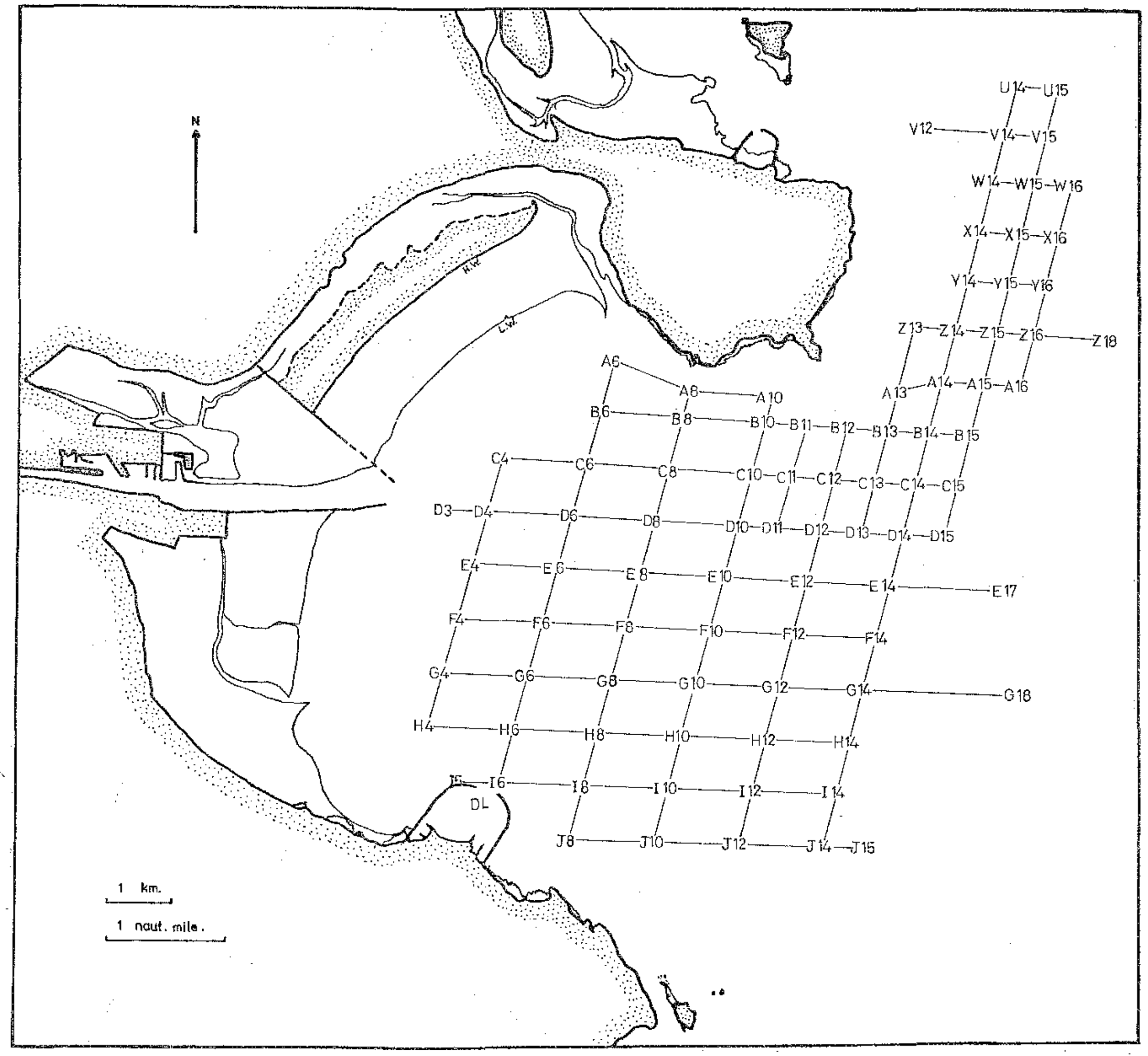

FIG. 1b. Sampling grid with station denominations.

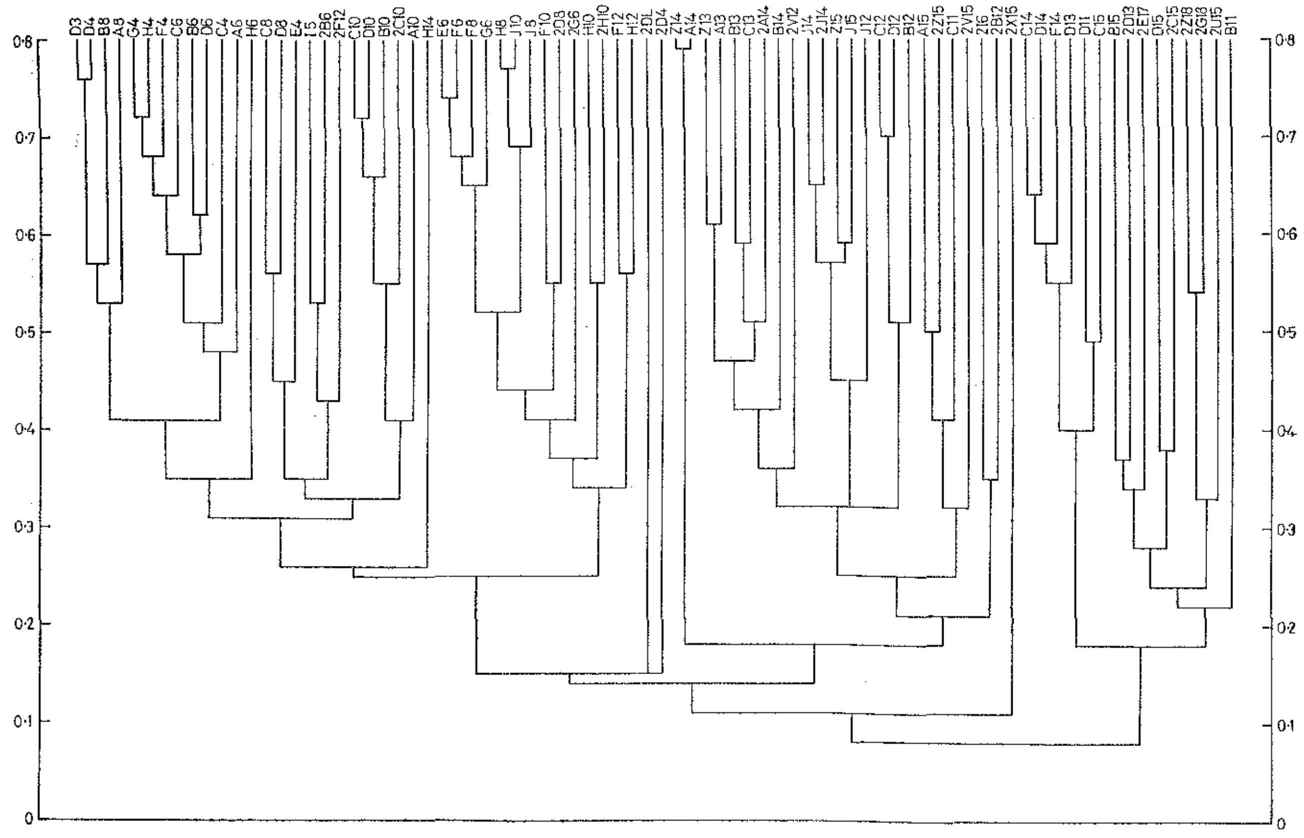

FIG. 2. Dendrogram showing faunal relationships between all samples. The 1972 samples are prefixed by a 2.

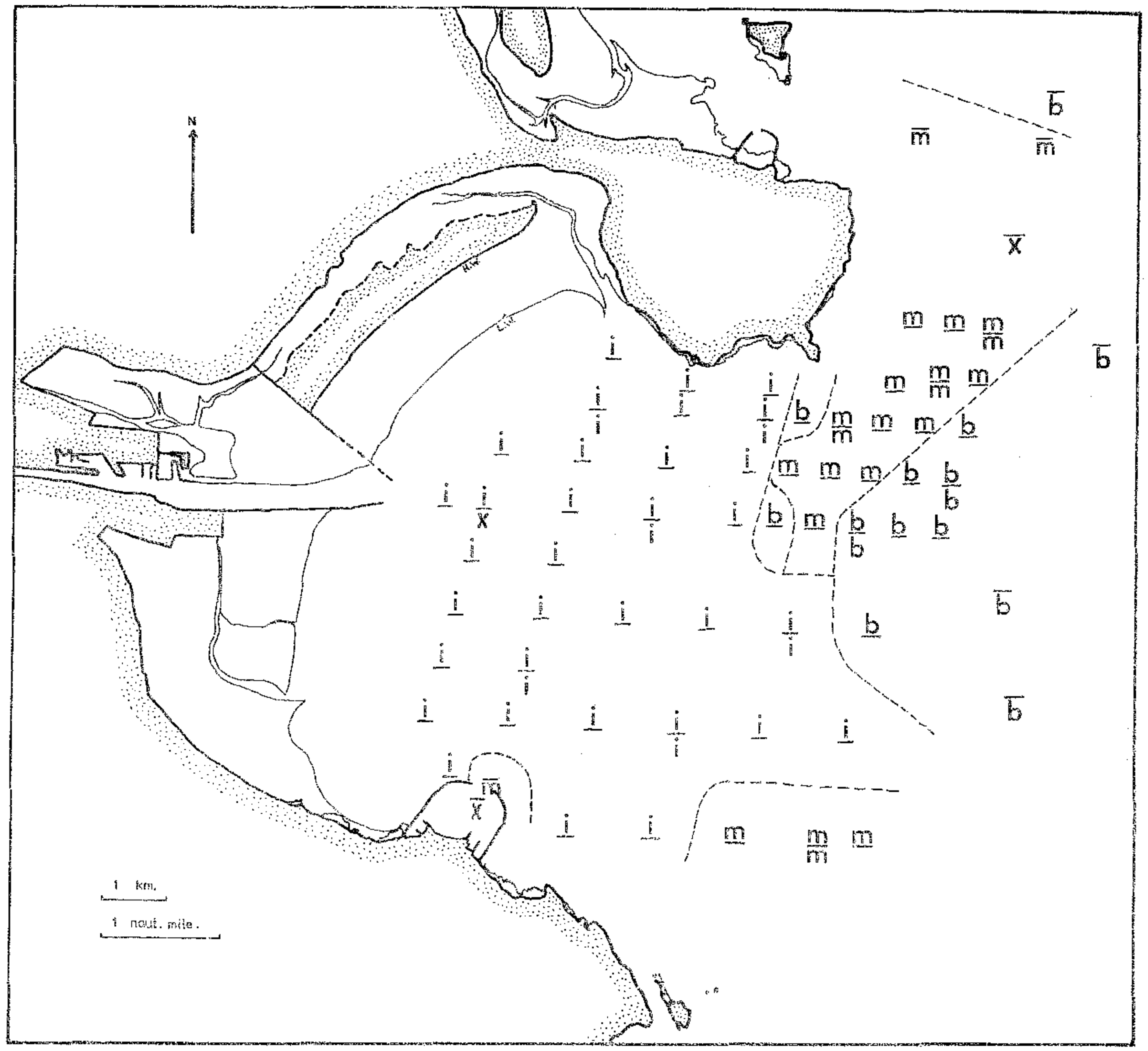

FIG. 3. Distribution of stations within the main faunal groups in the dendrogram (Fig. 2).
i, Group I stations, mainly Inshore
m, Group II stations, Muddy
b, Group III stations, mainly on sandBanks.
1971 stations above and 1972 stations below the lines. X represents a non-aligned station.

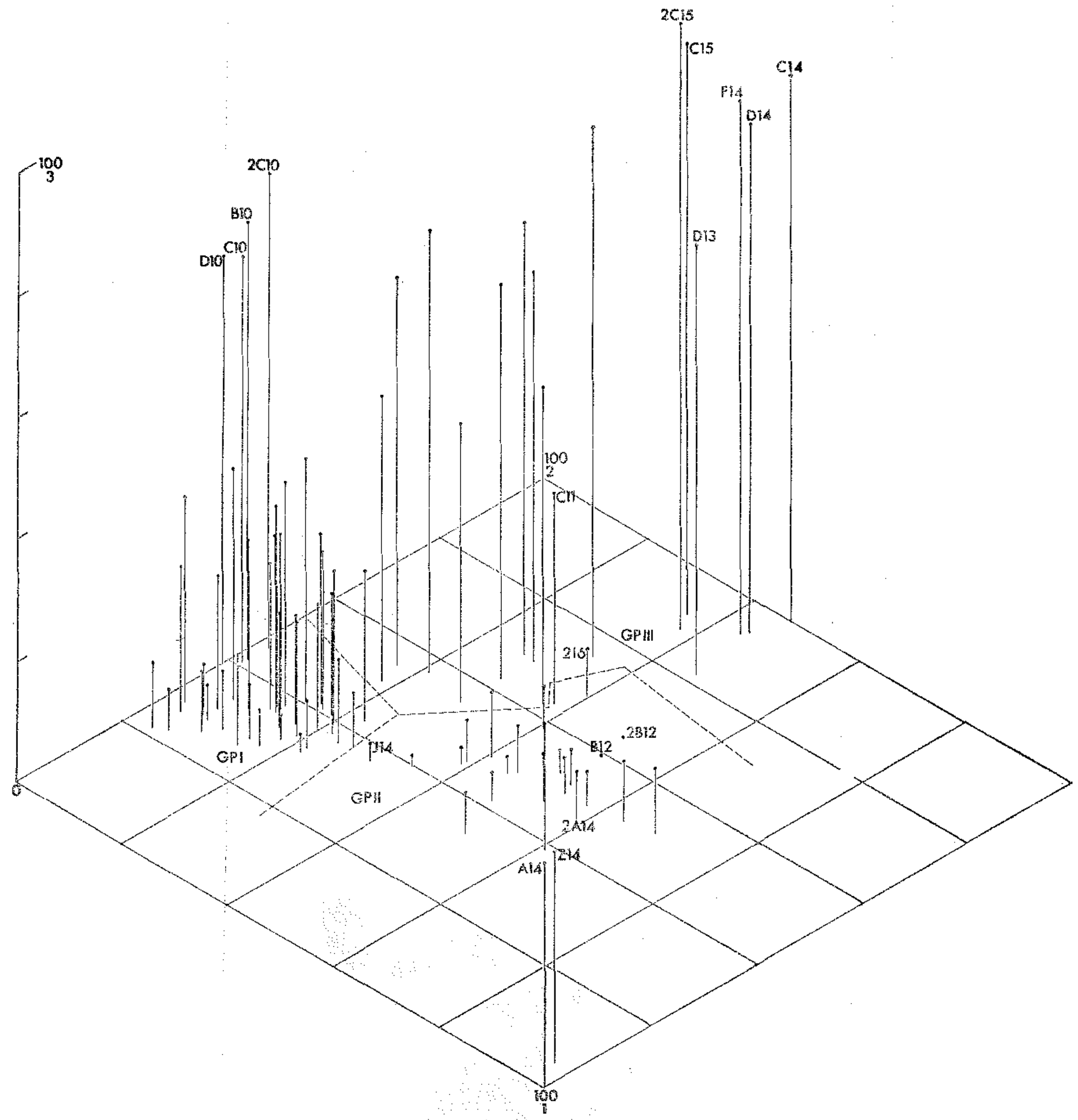

FIG. 4. Three dimensional diagram showing the distribution of stations on reciprocal averaging Axes 1, 2 and 3. Only selected stations are named. Eigenvalues (see Hill, 1973a) are as follows:

Axis 1 0.618.
,, 2 0.451.
,, 3 0.427.

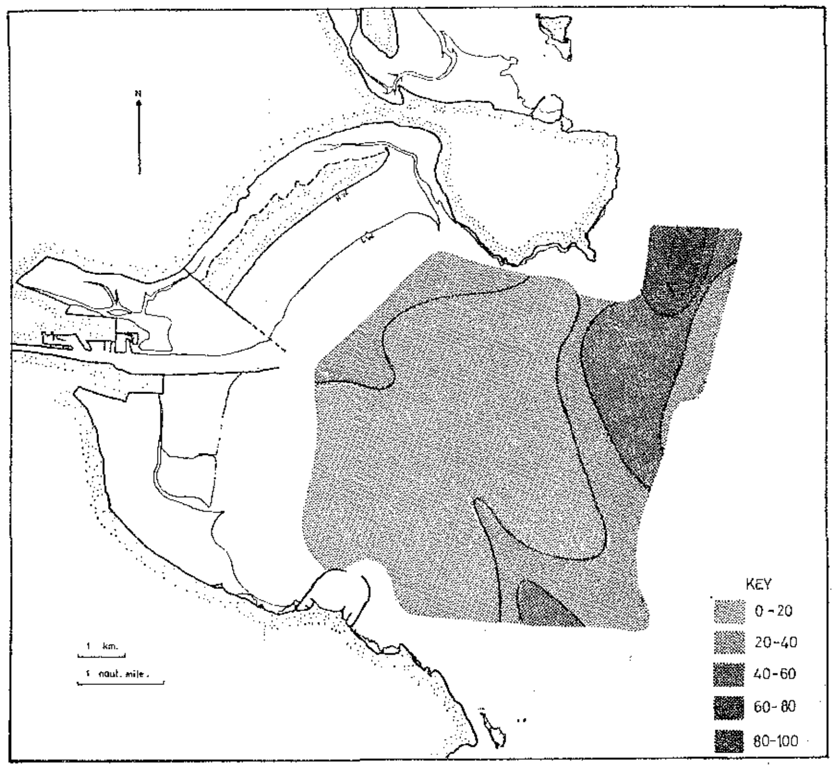

FIG. 5. Contoured map of the 1971 values for reciprocal averaging Axis 1.

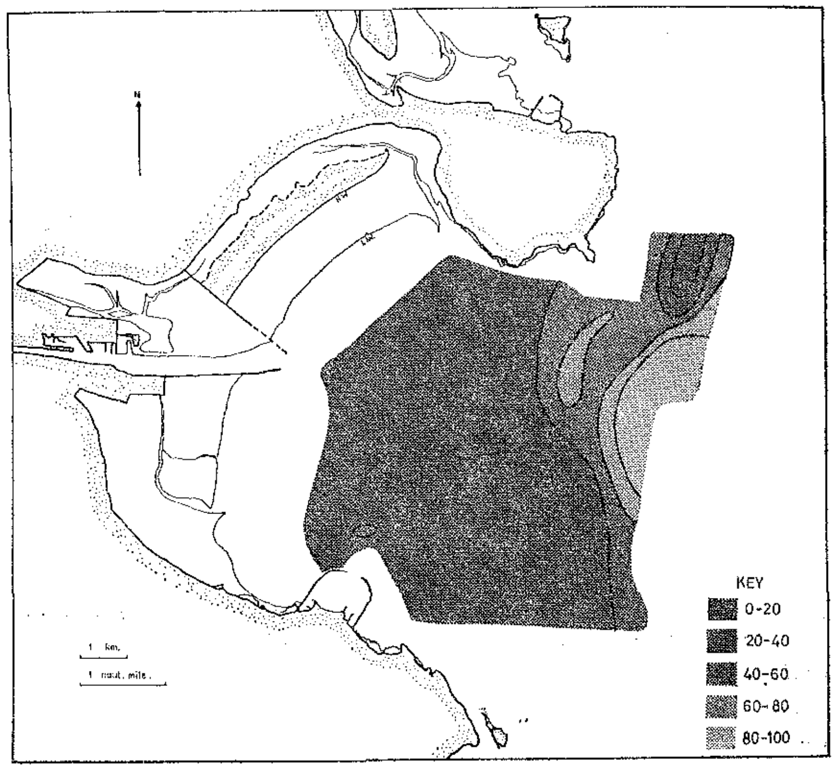

FIG. 6. Contoured map of the 1971 values for reciprocal averaging Axis 2.

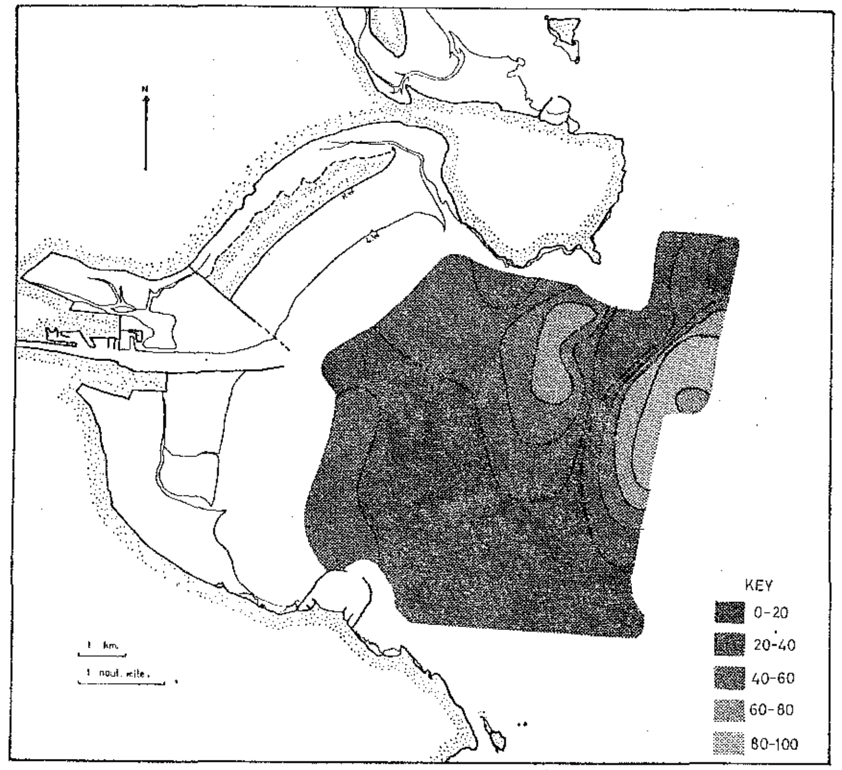

FIG. 7. Contoured map of the 1971 values for reciprocal averaging Axis 3.

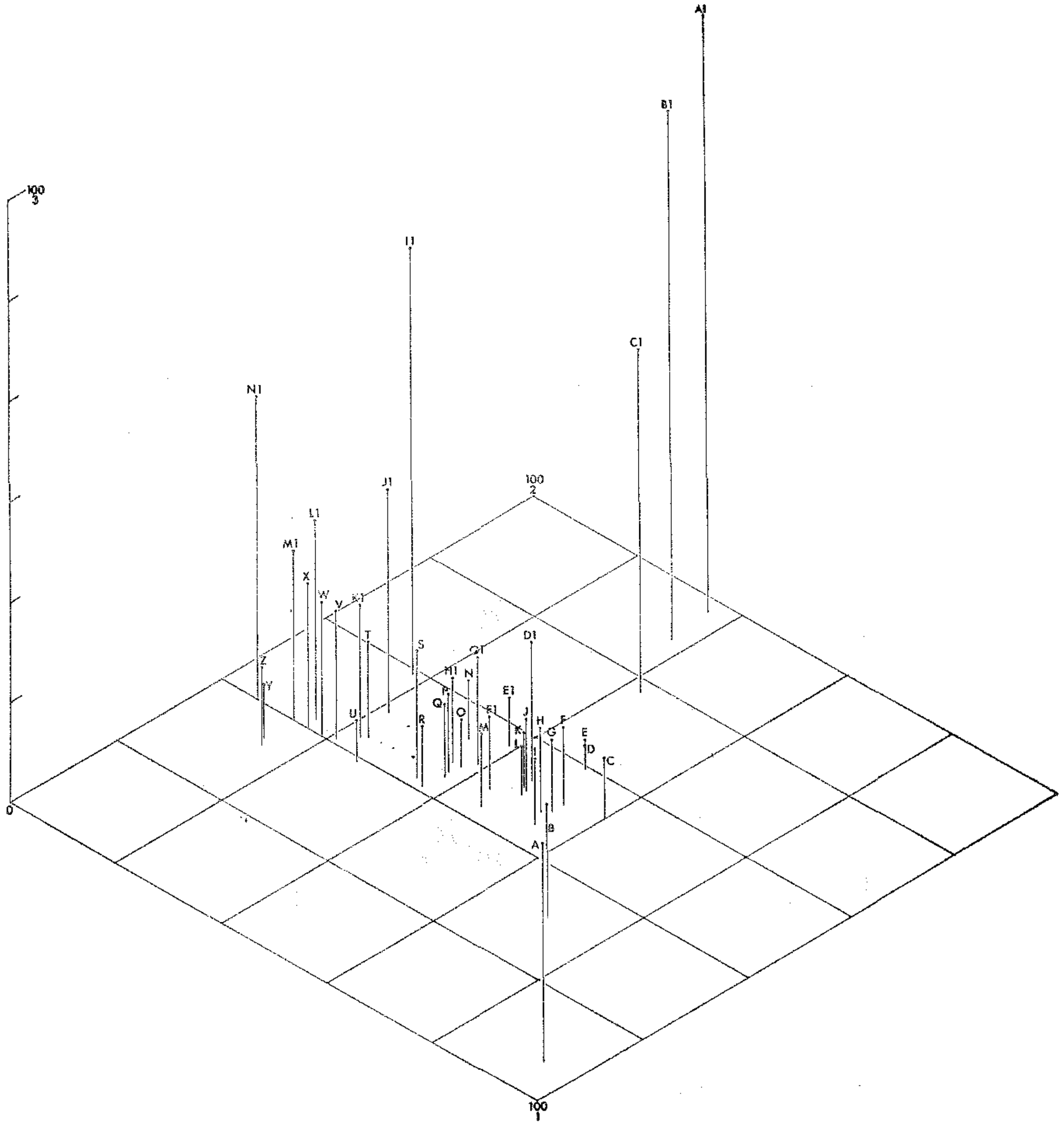

FIG. 8. Three dimensional diagram showing the distribution of 40 annelid species on Axes 1, 2 and 3.

Key:

A	*Cirratulus filiformis*	O	*Phyllodoce* spp.	A1	*Microphthalmus similis*
B	*Nephtys ciliata*	P	*Owenia fusiformis*	B1	*Ophelia borealis*
C	*Cirratulus cirratus*	Q	*Notomastus latericeus*	C1	*Polycirrus* sp.
D	*Peloscolex benedeni*	R	*Ampharete acutifrons*	D1	*Scoloplos armiger*
E	*Cirriformia tentaculata*	S	*Spio filicornis*	E1	*Lanice conchilega*
F	*Eusyllis blomstrandi*	T	*Sthenelais limicola*	F1	*Pectinaria auricoma*
G	*Mediomastus fragilis*	U	*Caesicirrus neglectus*	G1	*Lumbrineris gracilis*
H	*Caulleriella alata*	V	*Capitella capitata*	H1	*Pectinaria koreni*
I	*Scalibregma inflatum*	W	*Nephtys hombergii*	I1	*Nephtys cirrosa*
J	*Gyptis capensis*	X	*Spiophanes bombyx*	J1	*Nephtys longosetosa*
K	*Pholoë minuta*	Y	*Myriochele* sp.	K1	*Eumida sanguinea*
L	*Sthenelais boa*	Z	*Prionospio malmgreni*	L1	*Chaetozone setosa*
M	*Nereis* spp.			M1	*Sigalion mathildae*
N	*Nephtys caeca*			N1	*Magelona mirabilis*

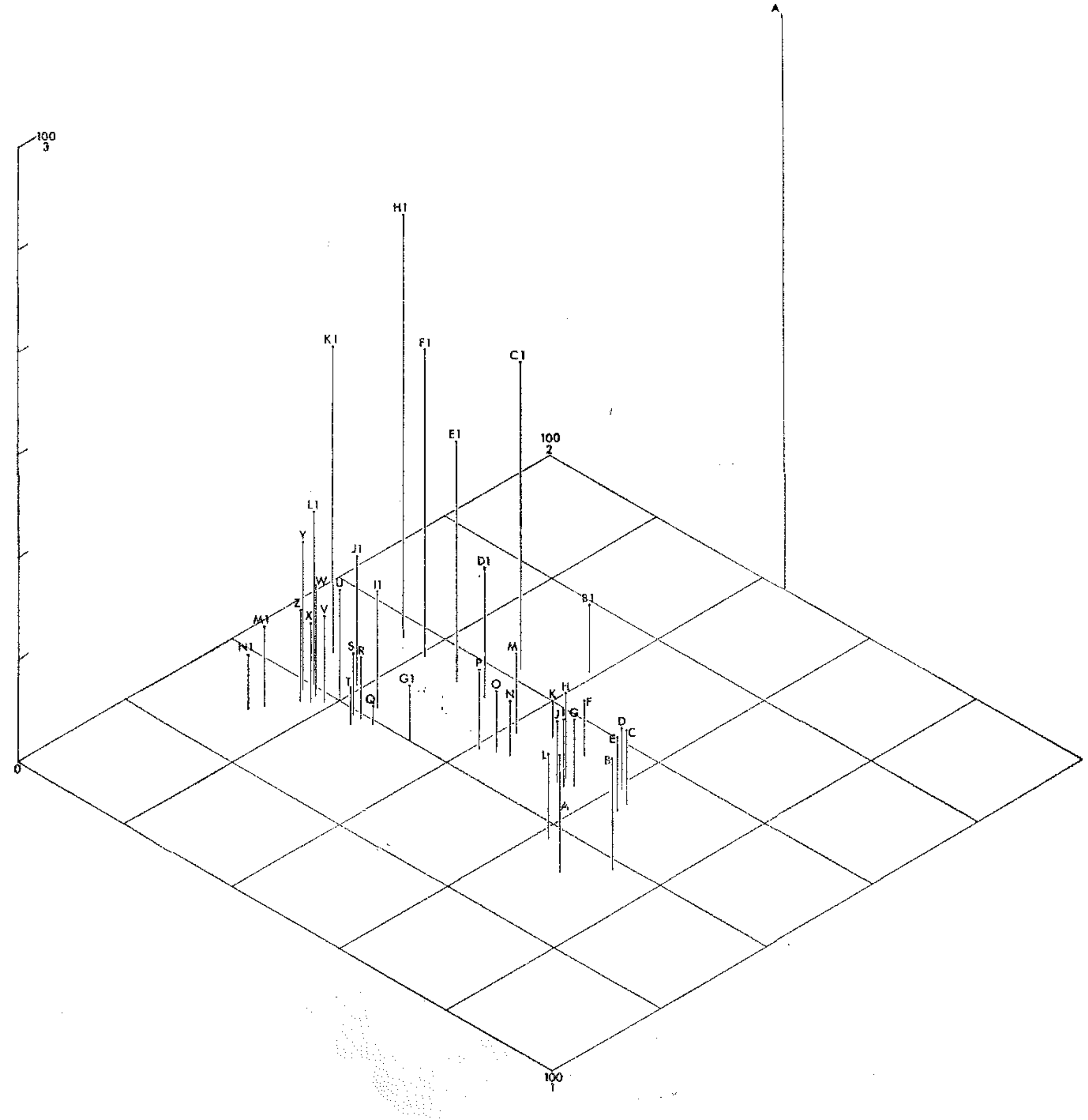

FIG. 9. Three dimensional diagram showing the distribution of 40 non-annelid species on Axes 1, 2 and 3.

Key:

A	*Venerupis pullastra*	O	*Ophiothrix fragilis*	A1	*Echinocardium flavescens*
B	*Amphipholis squamata*	P	*Lucinoma borealis*	B1	*Urothoë elegans*
C	*Ampelisca diadema/tenuicornis*	Q	*Nucula tenuis*	C1	*Echinocardium cordatum*
D	*Asterias rubens*	R	*Phoronis mülleri*	D1	*Abra tenuis*
E	*Erichthonius brasiliensis*	S	*Cultellus pellucidus*	E1	*Spisula elliptica*
F	*Photis pollex*	T	*Thyasira flexuosa*	F1	*Abra prismatica*
G	*Mya arenaria*	U	*Ophiura* sp. (small)	G1	*Abra alba*
H	*Cerianthus lloydi*	V	*Dosinia* sp.	H1	*Bathyporeia elegans*
I	*Sagartia troglodytes*	W	*Venus striatula*	I1	*Gari fervensis*
J	*Photis longicaudata*	X	*Ophiura albida*	J1	*Ampelisca typica*
K	*Ampelisca spinipes*	Y	*Acrocnida brachiata*	K1	*Bathyporeia tenuipes*
L	*Nucula nucleus*	Z	*Ampelisca brevicornis*	L1	*Tellina fabula*
M	*Tubulanus polymorphus*			M1	*Nucula turgida*
N	*Mysella bidentata*			N1	*Ophiura texturata*

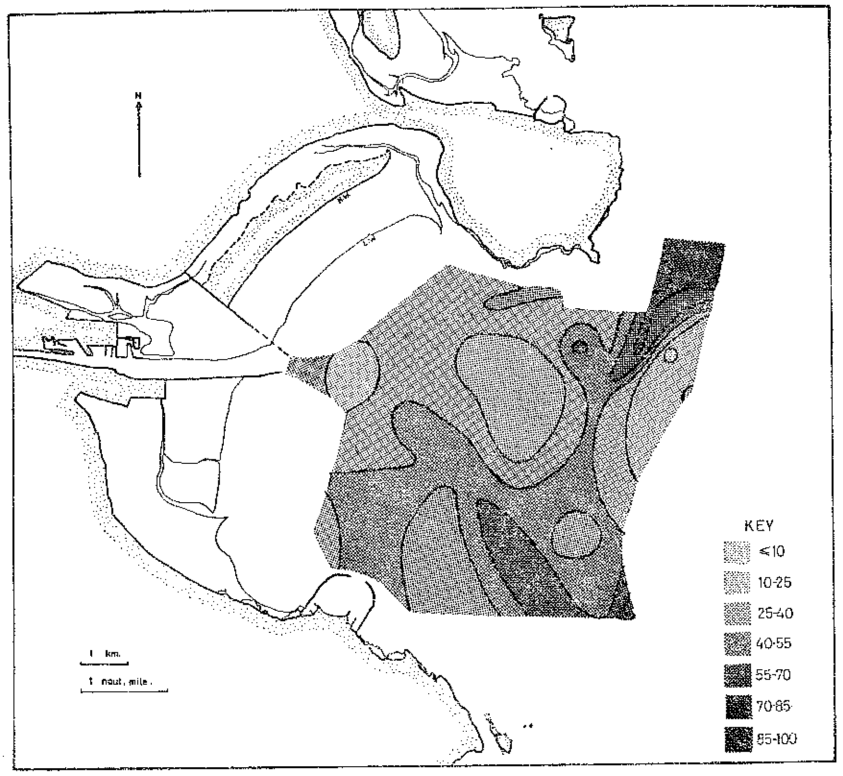

FIG. 10. Contoured map of the distribution of species per station ($0.2m^2$), 1971.

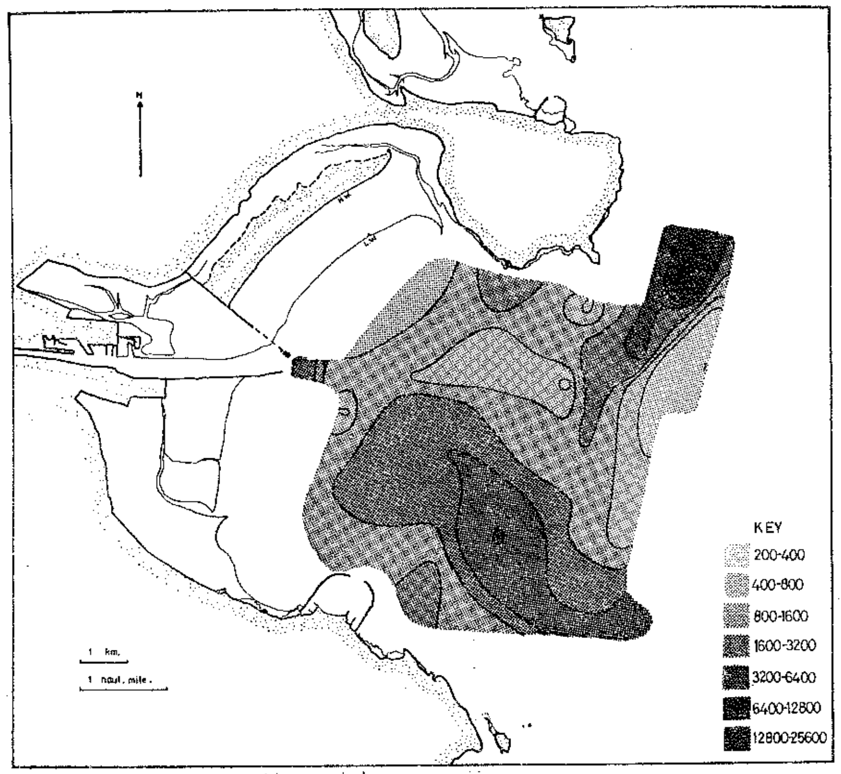

FIG. 11. Contoured map of the distribution of individuals per m^2, 1971.

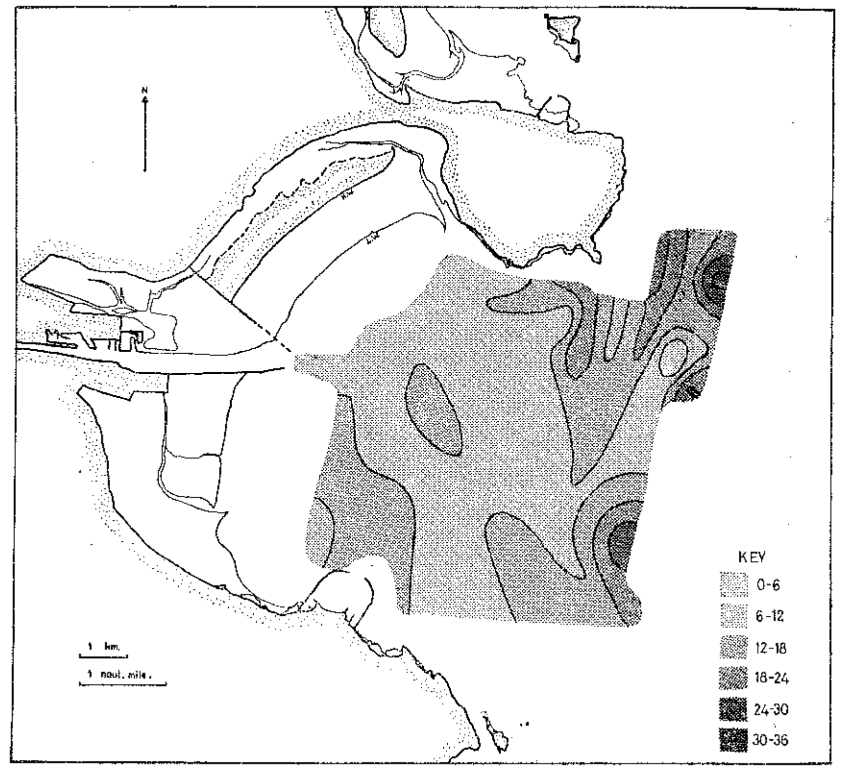

FIG. 12. Contoured map of diversity, Fisher, Corbet and Williams α, 1971.

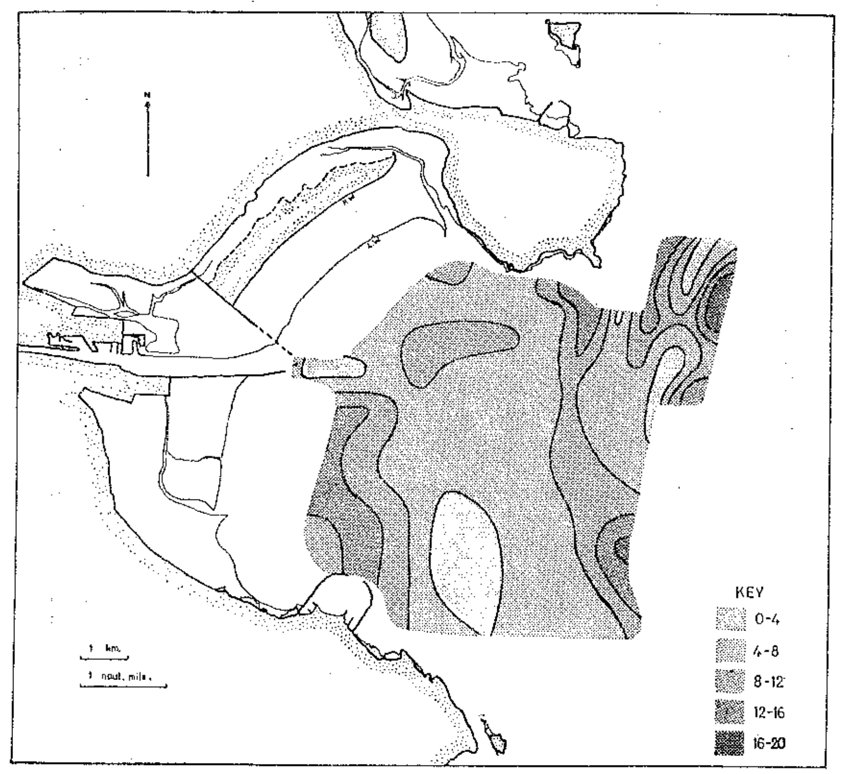

FIG. 13. Contoured map of Hill's diversity, 1971.

TABLE 1. Physical characteristics of the environments, mean numbers of species,* individuals and diversities (α) of the associated groups of stations produced by the classification analysis.

Group	Number of Stations	Depth (m)		Mean Grain Size (phi)		Sorting Coefficient (Standard Deviation, phi)		Percent Volume of Fines		Species per $0.2m^2$		Individuals per $0.2m^2$		Diversity (α)	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
I	39	9.9	4-24	2.93 (0.14 mm)	3.57-1.65 (0.08-0.32 mm)	0.81	0.46-1.65	11.7	1-37	35.9	20-73	311 (1555 per m^2)	75-1382 (375-6910 per m^2)	11.6	6-28
II	23 (no sediment sample for J 12)	26.5	9-32	2.58 (0.18 mm)	4.01-1.39 (0.06-0.38 mm)	1.48	0.93-2.22	31.6	8-70	70.3	33-89	823 (4115 per m^2)	247-2985 (1235-14925 per m^2)	20.0	10-33
III	15	22.2	11-28	1.80 (0.29 mm)	2.34-1.20 (0.20-0.43 mm)	0.78	0.46-1.18	4.0	0-10	25.7	6-40	73 (365 per m^2)	44-132 (220-660 per m^2)	15.8	2-30

* For single dip (0.1 m^2) samples an approximate 0.2 m^2 species value was estimated by first finding the diversity (α) of the original 0.1 m^2 sample, then reading off the value for species for a sample with this diversity but with twice the number of individuals.

'ABLE 2. Group I. Species found at ≥ 14 stations (36% occurrence), and/or with a maximum density ≥ 10 individuals per station (50 per m^2).

'pecies	Percent occurrence	Mean density per m^2 (for all stations in the group)	Maximum density per m^2
Nemertini			
Tubulanus polymorphus	44	5	30
Annelida			
Ampharete acutifrons	51	8	45
Aricidea minuta	5	2	80
Caesicirrus neglectus	64	74	870
Capitella capitata	62	15	155
Chaetozone setosa	95	39	175
Clymene affinis	5	4	125
Eteone longa	51	5	25
Eumida sanguinea	51	19	180
Lanice conchilega	67	30	200
Magelona mirabilis	74	63	325
Mediomastus fragilis	39	8	55
Melinna palmata	28	4	55
Myriochele sp.	82	136	1150
Nephtys hombergii	97	56	125
Notomastus latericeus	41	9	60
Owenia fusiformis	51	8	50
Poecilochaetus serpens	18	6	90
Prionospio malmgreni	67	75	585
Scoloplos armiger	49	9	65
Sigalion mathildae	72	9	55
Spio filicornis	82	22	80
Spiophanes bombyx	100	52	145

Species	Percent occurrence	Mean density per m^2 (for all stations in the group)	Maximum density per m^2
Arthropoda			
Ampelisca brevicornis	64	37	250
Harpinia antennaria	36	12	100
Iphinoë trispinosa	28	10	140
Photis longicaudata	15	3	55
Synchelidium maculatum	49	5	30
Urothoë elegans	15	4	105
Mollusca			
Abra alba	100	306	3225
Cultellus pellucidus	39	5	60
Ensis ensis	41	5	60
Mysella bidentata	44	5	50
Natica alderi	36	2	10
Nucula turgida	95	224	910
Tellina fabula	100	87	235
Thyasira flexuosa	49	36	580
Venus striatula	69	13	70
Phoronidea			
Phoronis mülleri	49	9	155
Ophiuroidea			
Acrocnida brachiata	62	5	20
Ophiura albida	26	5	60

TABLE 4. Group III. Species found at ≥ 5 stations (33% occurrence) and/or with a maximum density ≥ 5 individuals per station (25 per m^2).

Species	Percent occurrence	Mean density per m^2 (for all stations in the group)	Maximum density per m^2
Nemertini			
Species w.	40	4	10
Annelida			
Caesicirrus neglectus	60	5	10
Chaetozone setosa	67	13	80
Cirratulus filiformis	13	2	25
Glycera lapidum	20	6	60
Lumbrineris gracilis	33	7	50
Mediomastus fragilis	47	8	50
Microphthalmus similis	7	2	30
Myriochele sp.	40	5	20
Nephtys cirrosa	87	18	60
Nephtys hombergii	67	5	15
Nephtys longosetosa	33	3	20
Ophelia borealis	40	4	25
Owenia fusiformis	40	3	10
Paraonis lyra	33	2	5
Pisione remota	13	2	30
Polycirrus sp.	87	68	195
Scoloplos armiger	93	13	150
Sigalion mathildae	7	3	40
Spio sp.	20	15	130
Spiophanes bombyx	53	14	90
Travisia forbesii	33	9	60

Species	Percent occurrence	Mean density per m^2 (for all stations in the group)	Maximum density per m^2
Arthropoda			
Bathyporeia elegans	53	7	30
Bathyporeia tenuipes	13	3	40
Diastylis bradyi	40	4	20
Synchelidium maculatum	47	6	20
Urothoë elegans	47	9	40
Mollusca			
Abra alba	33	2	15
Abra prismatica	40	5	20
Corbula gibba	20	3	30
Spisula elliptica	33	2	10
Tellina fabula	47	9	40
Echinoidea			
Echinocardium cordatum	33	5	20

TABLE 3. Group II. Species found at ≥ 9 stations (39% occurrence) and/or with a maximum density ≥ 25 individuals per station (125/m²).

Species	Percent occurrence	Mean density per m² (for all stations in the group)	Maximum density per m²
Anthozoa			
Cerianthus lloydi	78	13	35
Sagartia troglodytes	61	9	35
Nemertini			
Species p.	39	2	10
Tubulanus polymorphus	91	29	135
Annelida			
Ampharete acutifrons	78	23	65
Caesicirrus neglectus	74	100	670
Capitella capitata	48	7	50
Caulleriella alata	87	40	130
Cirratulus cirratus	39	6	60
Cirratulus filiformis	70	815	10440
Cirriformia tentaculata	65	39	405
Eteone flava	39	7	55
Eteone longa	57	6	50
Eumida sanguinea	61	12	75
Eusyllis blomstrandi	65	11	45
Gattyana cirrosa	48	10	60
Glycera lapidum	48	9	65
Gyptis capensis	48	5	20
Harmothoë spinifera/extenuata	44	8	60
Lanice conchilega	87	218	1940
Lumbrineris gracilis	78	13	50
Malacoceros ciliata/girardi	48	12	50
Mediomastus fragilis	100	334	1270
Melinna cristata	39	7	40
Myriochele sp.	83	42	290
Nephtys hombergii	70	17	60
Nereis spp.	61	7	25
Notomastus latericeus	78	15	50
Ophelina acuminata	48	7	25
Owenia fusiformis	83	32	135
Pectinaria auricoma	48	3	15
Pectinaria koreni	52	5	30
Peloscolex benedeni	57	92	620
Pholoë minuta	91	32	110
Phyllodoce maculata	61	16	85
Phyllodoce mucosa	61	29	355
Poecilochaetus serpens	48	3	20
Polycirrus sp.	78	30	310
Polydora caulleryi	39	21	165
Pomatoceros triqueter	52	19	130
Pseudopolydora pulchra	44	10	50
Sabellaria spinulosa	13	8	160
Scalibregma inflatum	87	35	125
Scoloplos armiger	96	90	265
Spio filicornis	78	38	130
Sthenelais boa	70	13	70
Tharyx marioni	39	4	30
Arthropoda			
Ampelisca diadema/tenuicornis	65	122	860
Ampelisca spinipes	78	32	145
Anoplodactylus petiolatus	48	13	130
Balanus crenatus	35	72	550
Corophium bonelli	30	14	205
Erichthonius brasiliensis	30	12	145
Harpinia antennaria	70	35	200
Melita obtusata	44	12	125
Nymphon rubrum	61	11	50
Orchomenella nana	39	2	10
Pagurus bernhardus	39	4	15
Photis longicaudata	78	105	380
Photis pollex	52	8	50
Stenothoë marina	39	3	20
Tanaidacea sp.	52	8	50
Urothoë elegans	65	139	2430
Mollusca			
Abra alba	96	544	1645
Lucinoma borealis	70	6	15
Mya arenaria	78	27	115
Mysella bidentata	91	61	250
Natica alderi	57	7	25
Nucula nucleus	78	222	1115
Nucula turgida	44	27	205
Thyarisa flexuosa	87	25	200
Venerupis pullastra	44	9	70
Phoronidea			
Phoronis mülleri	48	9	55
Ophiuroidea			
Ophiothrix fragilis	39	13	130

TABLE 5. Species ≥ 50% occurrence in a particular group and < 20% occurrence in the remaining groups (community group characterizing species).

Group	Species	Percent occurrence	Percent occurrence and group where otherwise most widespread	
Group I.	*Sigalion mathildae*	72	7	III
	Acrocnida brachiata	62	9	II
Group II.	*Caulleriella alata*	87	15	I
	Scalibregma inflatum	87	7	III
	Cerianthus lloydi	78	13	III
	Ampelisca spinipes	78	8	I
	Mya arenaria	78	absent elsewhere	
	Nucula nucleus	78	7	III
	Cirratulus filiformis	70	13	III
	Sthenelais boa	70	8	I
	Lucinoma borealis	70	7	III
	Cirriformia tentaculata	65	10	I
	Eusyllis blomstrandi	65	10	I
	Ampelisca diadema/tenuicornis	65	7	III
	Sagartia troglodytes	61	8	I
	Nereis spp.	61	18	I
	Phyllodoce maculata	61	8	I
	Nymphon rubrum	61	7	III
	Peloscolex benedeni	57	10	I
	Pomatoceros triqueter	52	7	III
	Photis tenuicornis	52	8	III
	Tanaidacea sp.	52	15	I
Group III.	*Nephtys cirrosa*	87	15	I
	Bathyporeia elegans	53	18	I

TABLE 6. Widespread species with ≥ 80% occurrence in one or more groups, and > 33% in at least one other group.

Species	Groups where occurrence ≥ 80%	Groups where occurrence 33-79%
Tubulanus polymorphus	II	I
Chaetozone setosa	I	III
Lanice conchilega	II	I
Mediomastus fragilis	II	III, I
Myriochele sp.	II, I	III
Nephtys hombergii	I	II, III
Owenia fusiformis	II	I, III
Polycirrus sp.	III	II
Scoloplos armiger	III, II	I
Spio filicornis	I	II
Spiophanes bombyx	I	III
Abra alba	I, II	III
Mysella bidentata	II	I
Nucula turgida	I	II
Tellina fabula	I	III
Thyasira flexuosa	II	I

TABLE 8. Similarity coefficients between samples taken from the same station in 1971 and 1972.

Station	Similarity	Station	Similarity
D4	0.17	F12	0.45
B6	0.34	D13	0.36
G6	0.50	A14	0.22
D8	0.53	J14	0.65
C10	0.57	Z15	0.35
H10	0.55	C15	0.24
B12	0.20		

TABLE 7. Correlation half-matrix ($0.2m^2$ stations only).

Key: A $P \leq 0.001$; B $P \leq 0.002$; C $P \leq 0.005$; D $P \leq 0.01$; E $P \leq 0.02$; F $P \leq 0.05$

Underlined symbols represent negative correlations

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Depth	1																													
Dist. from Liffey	2	A																												
% Vol. Fines	3	A	D																											
Mean Grain Size (mm)	4	A	A	C̲																										
Mean Grain Size (phi)	5	A̲	A̲	B	A̲																									
Sorting Coefficient (Standard Deviation)*	6	A	A	A																										
Tomato Pips	7	B	D	F			F																							
No. Species	8	A	A	A			A	B																						
No. Individuals	9	A	D	A	F̲		A	F	A																					
α Diversity	10	A	A		A	A̲	A	F	A																					
Hill's Diversity	11				B	A̲			E		A																			
Deposit Swallowers No. Species	12	A	A	A			A	F	A	B	A	C																		
Microvores No. Species	13	A	A	A			A	C	A	A	A	E	A																	
Carnivores No. Species	14	A	A	A			A	A	A	A	A	F	A	A																
Deposit Swallowers % Species	15	E	C		A	B̲							A	F̲																
Microvores % Species	16	A̲	A̲	D̲	C̲	D	B̲		F̲		D̲		A̲		C̲	A̲														
Carnivores % Species	17	C		C			A	F	A	A	E			A	A	C̲	A̲													
Deposit Swallowers No. Individuals	18	A	A	A			A		A	A	C		A	A	A		C̲	A												
Microvores No. Individuals	19	B	F	A	F̲	F	A	F	A	A		F̲	E	A	A			A	A											
Carnivores No. Individuals	20	A	D	A			A	D	A	A	A		A	A	A			A	A	A										
Deposit Swallowers % Individuals	21	A	A	A	E	E̲	A		C		A		A	F	E	A	A̲		A											
Microvores % Individuals	22	A̲	A̲		A̲	A					A̲	A̲	A̲			A̲	A		F̲	D		A̲								
Carnivores % Individuals	23			A̲	C	D̲	E̲		C̲	A̲		A		B̲	E̲				A̲	A̲			A̲							
Ordination Axis 1	24	A	A	A	F		A	D	A	A	A		A	A	A	F	A	E	A	A	A	A	D̲							
Ordination Axis 2	25	F	C	F̲	A	A̲				A̲				E̲		A	B̲			A̲		A	A̲	B						
Ordination Axis 3	26			A̲	A	A̲	A̲		A̲	C̲			C̲	A̲	A̲	E		D̲	A̲	E̲	A̲			A		A				
Ordination Axis 4	27		F		A	A̲										D	F̲									D	E			
Ordination Axis 5	28	E	C		A	A̲							F			A	A̲	F̲				C	E̲		E	A	A	A		
Loss on Ignition (1972 only)	29			A			E												F											

* Therefore high values indicate poor sorting.

TABLE 9. Prominent animals in samples not fully identified (1972).

Station	Prominent fauna
2D3	*Nephtys, Notomastus,* tubes (?*Lanice*)
2C4	*Venus striatula, Cerebratulus/Micrura, Nephtys, Ensis, Tellina fabula,* tubes (?*Lanice*)
2E4	*Lanice, Philine, Nephtys, Eumida*
2D6	*Spisula, Nereis, Nephtys, Macropipus,* tubes (?*Lanice*)
2A10	*Philine,* tubes (?*Lanice*)
2B10	*Echinocardium, Tellina fabula, Nephtys*
2D10	*Nephtys,* tubes (?*Lanice*)
2B11	*Nephtys*
2C11	—
2D11	Tubes (?*Lanice*)
2C12	*Nephtys*
2D12	*Nephtys*
2Z13	*Nucula, Macropipus, Pomatoceros*
2A13	*Abra alba, Nucula, Sthenelais*
2B13	*Abra alba, Nucula*
2C13	*Nucula,* tubes (?*Lanice*)
2U14	*Echinocardium, Nephtys, Ophelia*
2V14	*Nephtys, Melinna, Lumbrineris, Philine, Ophiura, Mya*
2W14	*Nephtys, Ampharete, Abra alba, Sagartia, Ampelisca, Thyasira, Pectinaria*
2X14	*Sthenelais, Owenia, Abra alba, Nucula*
2Y14	*Nephtys, Notomastus, Abra alba, Mya, Nucula*
2Z14	*Abra alba, Ophiothrix*
2B14	*Ophelia,* Spionid, Actinian
2C14	*Ophelia, Nephtys,* tubes (?*Lanice*)
2D14	*Nephtys*
2W15	Hydroids, Ascidian, *Pycnogonum*
2Y15	*Abra alba, Cirriformia, Sthenelais, Nephtys, Venerupis, Mya*
2A15	*Echinocardium, Nucula, Cerebratulus/Micrura, Ebalia tumefacta*
2B15	*Echinocardium*
2D15	*Nephtys, Spisula*
2W16	*Echinocardium*
2X16	*Eubranchus, Glycera*
2Y16	*Ampelisca, Cerebratulus/Micrura, Nephtys, Melinna, Tellina fabula Glycera*
2Z16	*Sthenelais, Macropipus, Cerebratulus/Micrura, Pagurus, Magelona, Nucula*
2A16	*Scoloplos, Glycera, Nephtys, Nucula, Nymphon*

TABLE 10. Faunal data per total sample and first three axis scores for the 1972 stations.

Sample	Species	Individuals	Diversities α	Diversities Hill's	Axis scores 1	Axis scores 2	Axis scores 3
2D4	21	99	8	4.5	41	59	7
2B6	33	178	12	9.4	17	41	26
2G6	55	547	15	4.9	7	28	9
2I6*	65	516	20	—	40	68	8
2DL*	61	712	15	—	8	28	6
2D8	26	204	8	8.1	7	31	22
2C10	22	158	7	5.7	2	46	78
2H10	73	913	18	10.7	18	32	4
2V12*	63	362	23	—	53	52	6
2B12	81	1152	20	7.2	50	65	0
2F12	52	217	22	15.3	16	42	28
2D13	40	91	27	18.7	37	63	52
2A14	75	557	23	13.8	59	47	8
2J14	72	1007	18	7.5	35	40	2
2U15*	21	37	20	—	18	51	47
2V15*	47	144	25	—	39	46	7
2X15*	29	61	20	—	54	50	6
2Z15	72	268	31	26.4	46	49	8
2C15	19	57	10	4.2	38	88	100
2E17*	25	36	30	—	17	55	64
2Z18*	30	66	20	—	29	55	46
2G18*	19	59	10	—	29	63	65

* Hill's diversity was not calculated for stations where only one grab lowering ($0.1m^2$) was taken. It must be remembered that the species and individuals totals for these nine stations relate to this area, rather than the $0.2m^2$ of the other 13 stations.

TABLE 11. Data sources and list of genera in feeding categories.

DATA SOURCES.

General: Blegvad (1914), Hardy (1959), Holme (1916a), Howard and Frey (1975), Hunt (1925), Mare (1942), Pearson (1971a), Rhoads (1974), Sanders (1956), Sanders *et al.* (1962), Savilov (1957), Thorson (1966, 1971), Turpaeva (1957), Yonge (1949, 1954a and b), Zatespin (1970).

Anthozoa: The late Mr. D. Huxtable (pers. comm.), Buhr and Winter (1977), Stephenson (1928, 1935), Tiffon (1975).

Nematoda: Dr. A. R. Ward (pers. comm.).

Nemertini: Gibson (1972).

Annelida: Professor R. P. Dales, Dr. B. Healy, Professor O. Vahl (all pers. comm.), Brinkhurst and Jamieson (1971), Buhr (1976), Clark (1962), Dales (1955, 1957, 1963), Day (1967a and b), Fordham (1925), Hartmann-Schröder (1971), Ockelmann and Vahl (1970), Rasmussen (1973), Warwick and Price (1975), Watling (1975), Whitlatch (1974), Wolff (1973), Ziegelmeir (1952, 1969).

Crustacea: Professor J. L. Barnard, Dr. D. A. Jones, Dr. N. S. Jones, Dr. A. A. Myers (all pers. comm.), Caine (1974), Dennell (1934), Dixon (1944), Enequist (1949), Forsman (1938), Foxon (1936), Gerlach, Ekstrøm and Eckardt (1976), Hartnoll (1963), Kanneworff (1965), Marshall and Orr (1960), Nicol (1932), Nicolaisen and Kanneworff (1969), Orton (1927), Pirlot (1932).

Mollusca: Allen (1953), Graham (1955), Holme (1961b), Morton (1958), Pohlo (1969), Trevallion (1971), Turk (1973), Yonge and Thompson (1976).

Echinodermata: Buchanan (1966), Mortensen (1927), Nagabhushanam and Colman (1959), Roushdy and Hansen (1960), Vevers (1956), Woodley (1975).

LIST OF GENERA IN FEEDING CATEGORIES (family names and higher taxa appertain to animals not identified beyond this level).

DEPOSIT SWALLOWERS

Polychaeta.			
Caesicirrus	*Clymene*	*Nicomache*	*Orbinia*
Capitella	*Leiochone*	*Notomastus*	*Scalibregma*
Capitellidae	Maldanidae	*Ophelia*	*Scoloplos*
?Capitomastus	*Mediomastus*	*Ophelina*	*Travisia*
Sipunculoidea			
Phascolion			
Other 'Vermes'			
Indeterminate genus			

MICROVORES

Anthozoa			
Metridium			
Nematoda			
Adoncholaimus	*Metalinhomoeus*	*Paralinhomoeus*	*Thoracostoma*
Polychaeta			
Ampharete	*Jasmineira*	*Pectinaria*	Sabellidae
Ampharetidae	*Lanice*	*Pista*	*Scolelepis*
Aonides	*Laonice*	*Poecilochaetus*	Serpulidae
Aricidea	*Magelona*	*Polycirrus*	*Spio*
Caulleriella	*Malacoceros*	*Polydora*	Spionidae
Chaetozone	*Melinna*	*Pomatoceros*	*Spiophanes*
Chone	*Myriochele*	*Prionospio*	*Stylaroides*
Cirratulidae	*Neoamphitrite*	*Pseudopolydora*	Terebellidae
Cirratulus	*Nicolea*	*Pygospio*	*Terebellides*
Cirriformia	*Owenia*	*Sabella*	*Tharyx*
Diplocirrus	*Paraonis*	*Sabellaria*	*Thelepus*
Flabelligera			
Ostracoda			
Cylindroleberis			
Cirripedia			

TABLE 11—(contd.)

Balanus	*Verruca*		
Malacostraca			
Ampelisca	*Diastylis*	*Melita*	*Pseudocuma*
Aora	*Erichthonius*	*Microprotopus*	*Siphonoecetes*
Bathyporeia	*Eudorella*	*Nototropis*	*Synchelidium*
Bodotria	*Eudorellopsis*	*Perioculodes*	Tanaidacea
Cheirocratus	*Iphinoë*	*Photis*	*Unciola*
Corophium	*Megaluropus*	*Pontocrates*	*Urothoë*
Cumacea	*Megamphopus*	*Porcellana*	
Gastropoda			
Capulus			
Pelecypoda			
Abra	*Donax*	*Montacuta*	*Tellina*
Acanthocardia	*Dosinia*	*Mya*	*Thracia*
Astarte	*Ensis*	*Mysella*	*Thyasira*
Chlamys	*Gari*	Mytilidae	*Venerupis*
Cochlodesma	Lamellibranchia	*Nucula*	*Venus*
Corbula	*Lucinoma*	*Parvicardium*	
Cultellus	*Mactra*	*Spisula*	
Phoronidea			
Phoronis			
Tunicata			
Ascidiacea	*Dendrodoa*	*Pelonaia*	

CARNIVORES-SCAVENGERS

Anthozoa			
Tealia			
Nemertini			
Cerebratulus/Micrura	Nemertini	*Tubulanus*	
Polychaeta			
Aphroditidae	*Glycinde*	*Notocirrus*	*Sthenelais*
Autolytus	*Goniada*	*Pholoë*	*Syllis*
Eteone	*Halosydna*	*Phyllodoce*	
Eulalia	*Harmothoë*	*Pisione* (but see footnote, page 17)	
Eumida	*Lumbrineris*		
Eusyllis	*Mystides*	*Scalisetosus*	
Glycera	*Nephtys*	*Sigalion*	
Priapuloidea			
Priapulus			
Copepoda			
Anomalocera			
Malacostraca			
Amphilocus	*Eurynome*	Lysianassidae	*Orchomenella*
Corystes	*Gnathia*	*Macropipus*	*Stenothoë*
Eurydice	*Lysianassa*	Megalopa larva	
Pycnogonida			
Anoplodactylus	*Nymphon*	Pycnogonida	*Pycnogonum*
Gastropoda			
Buccinum	*Natica*	*Philine*	*Scaphander*
Eubranchus			
Asteroidea			
Asterias			
Vertebrata			
Ammodytes	*Pholis*	Teleostii	

HERBIVORES

Nematoda	
Camacolaimus	
Deposit swallowers/Microvores	
Oligochaeta	
Peloscolex	Oligochaeta
Malacostraca	
Harpinia	
Echinodermata	
Echinocardium	*Leptosynapta*

TABLE 11—(contd.)

DEPOSIT SWALLOWERS/CARNIVORES-SCAVENGERS

Malacostraca
Hippomedon

MICROVORES/CARNIVORES-SCAVENGERS

Anthozoa			
Cerianthus	*Peachia*	*Sagartia*	*Sagartiogeton*
Edwardsia			
Nematoda			
Enoplus	Oncholaimidae		
Polychaeta			
Aphrodite	*Exogone*	*Kefersteinia*	*Ophiodromus*
Dorvillea	*Gattyana*	*Lepidonotus*	*Sphaerosyllis*
Ephesia	*Gyptis*	*Nereimyra*	Syllidia
Eunice	Hesionidae	*Nereis*	
Malacostraca			
Anapagurus	*Gastrosaccus*	Majidae	*Pandalina*
Caprellidae	*Hyas*	Mysidae	*Pandalus*
Crangon	*Macropodia*	*Pagurus*	
Ophiuroidea			
Acrocnida	*Ophiothrix*	*Ophiura*	Ophiuroidea
Amphipholis			

MICROVORES/HERBIVORES

Polychaeta
Microphthalmus

CARNIVORES-SCAVENGERS/HERBIVORES

Polyplacophora
Lepidopleurus

DEPOSIT SWALLOWERS/MICROVORES/CARNIVORES-SCAVENGERS

Malacostraca
Amphipoda

TABLE 12. Means and standard deviations for the numerical scores of the main feeding groups within the three community groups from the dendrogram ($0.2m^2$ stations only).

	Species per station						Individuals per station					
	Deposit Swallowers		Microvores		Carnivores		Deposit Swallowers		Microvores		Carnivores	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Gp I	3.4	1.9	22.8	7.6	9.9	4.2	26.0	45.6	254.5	205.1	30.8	14.1
Gp II	7.1	2.0	39.5	9.1	22.0	6.3	132.3	61.9	642.2	635.9	69.2	37.9
Gp III	4.5	1.6	13.9	4.1	6.6	3.3	11.8	8.5	40.1	11.1	13.6	7.4

TABLE 13. Means and standard deviations for the percentages of the main feeding groups within the three community groups from the dendrogram ($0.2m^2$ stations only).

	Species per station						Individuals per station					
	Deposit Swallowers		Microvores		Carnivores		Deposit Swallowers		Microvores		Carnivores	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Gp I	9.1	4.3	63.9	5.3	27.0	4.0	6.5	6.2	80.8	8.8	12.8	7.1
Gp II	10.7	3.0	57.3	3.8	31.9	4.2	19.8	10.1	70.4	10.8	9.9	4.8
Gp III	19.1	7.4	55.1	8.0	25.6	8.9	17.0	9.2	61.6	9.0	20.8	10.0

APPENDIX

Species were identified in 1971-73, before several up-to-date keys (e.g. most of the Linnean Society Synopses of the British fauna) were available. Not all taxa were included in the classification and ordination programmes, especially where identification was in doubt at the time. For the analyses several unidentified juvenile taxa were included with adults of the most appropriate species, as this is considered to be less inaccurate than treating such taxa separately.

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Numbers of each species (doubled where single dip sample) from the stations sampled (see Fig. 1b) i.e. per $0.2m^2$. Only stations are included for unquantifiable taxa.

Phylum Porifera

Porifera spp. *1971* Z13 A14 *1972* 2A14 2V15

Phylum Coelenterata

Class Hydrozoa

Abietinaria abietina (L.) *1971* Z13
Abietinaria filicula (Ellis & Solander) *1971* Z14 A15 *1972* 2Z18
Calicella syringa (L.) *1971* H6
Campanularia sp. *1972* 2E17
Campanularia volubilis (L.) *1971* Z14
Clytia hemisphaerica (L.) *1971* Z13 *1972* 2Z15
Halecium beani (Johnston) *1971* A14
Halecium halecinum (L.) *1971* D8 Z13 A15
Hydrallmania falcata (L.) *1971* D6 C8 J10 J12 Z13 A13 Z14 A14 A15 *1972* 2A14
Hydroidea spp. *1971* F8 C11 J14 A15
**Leuckartiara octona* (Fleming) *1971* J12 B13 A14 B14 J14 Z15 J15 *1972* 2A14 2Z15
Lovenella clausa Lovén *1972* 2F12
Nemertesia antennina (L.) *1971* A15 *1972* 2Z15
Obelia spp. *1971* D6 A10 C11 D11 F12 J12 Z13 A13 A14 F14 J14 A15 C15 J15 *1972* 2D4 2B6 2DL 2D8 2V12 2B12 2J14 2V15 2X15 2Z15 2Z18

* Epizoic on *Nucula nucleus*

Sertularella polyzonias (L.) *1971* A14
Sertularia cupressina L. *1971* H6 F12
Tubularia indivisa L. *1971* F6 F12 D14 *1972* 2D4 2DL 2J14

Class Anthozoa

Cerianthus lloydi Gosse *1971* A8—1 C11—1 C12—1 D12—1 J12—2 Z13—2 A13—2 B13—4 C13—5 Z14—6 A14—6 B14—2 Z15—2 *1972* 2I6—4 2H10—2 2V12—4 2B12—1 2D13—1 2A14—7 2V15—22 2Z15—5 2Z18—2
Edwardsia callimorpha (Gosse) *1971* C11—2 *1972* 2F12—1 2Z18—2
Metridium senile (L.) *1971* Z15—1
Peachia hastata Gosse *1971* G4—1 I5—2 A6—1 E6—3 F8—1 H8—1 H10—1 *1972* 2G6—1 2D8—2
Sagartia troglodytes (Price) *1971* B8—1 C12—3 D12—1 F12—1 Z13—7 A13—1 C13—3 Z14—2 A14—6 (? + 1) Z15—1 A15—1 J15—2 *1972* 2H10—1 2B12—3 2A14—3 2V15—2 (? + 2) 2Z15—3
Sagartiogeton undata (Müller) *1972* 2V15—2
Tealia felina (L.) *1971* C11—1
Virgularia mirabilis (Müller) *1971* F6 H10 *1972* 2DL 2H10 2X15

Phylum Nematohelminthes

Class Nematoda

Adoncholaimus sp. *1972* 2A14—8
Camacolaimus sp. *1972* 2A14—1
Enoplus sp. *1971* A13—1 *1972* 2A14—1
Metalinhomoeus sp. *1972* 2A14—1
Oncholaimidae sp. *1971* F4—2
Paralinhomoeus ? *donsi* Allgen *1971* A13—1
Thoracostoma sp. *1971* Z13—1 *1972* 2Z15—1

Phylum Nemertini

Cerebratulus/Micrura sp. *1971* D3—2 D4—1 F6—1 H6—1 F8—1 J8—1 F10—1 H10—2 F12—2 A13—1 B13—1 C13—1 B14—1 Z15—1 A15—1 *1972* 2H10—1 2V12—2 2V15—2
Nemertini sp. d/r (dark red; ?*Lineus* sp.) *1971* D12—3 Z14—1 A14—1
Nemertini sp. p (pink) *1971* C11—1 D12—1 F12—1 H12—1 A15—1 J15—1 *1972* 2G6—1 2H10—2 2V12—2 2B12—1 2A14—1 2V15—2 2Z15—1
Nemertini sp. u (unknown) *1971* D6—1 J10—1 J14—1
Nemertini sp. w (white) *1971* D3—1 G4—1 B6—1 E6—2 F6—1 B8—1 H8—1 J8—1 D10—1 H10—1 C11—1 Z13—1 C14—2 C15—2 J15—1 *1972* 2B6—1 2DL—2 2V12—24 2D13—1 2U15—2 2Z15—2 2E17—2 2Z18—2
Tubulanus annulatus (Montagu) *1971* Z13—1 C13—1 D13—1 A14—3 B14—1 J14—1 J15—1 *1972* 2H10—1 2B12—1
Tubulanus polymorphus (Renier) *1971* D3—1 E6—2 G6—2 H6—2 A8—1 F8—2 A10—2 B10—1 C10—1 F10—3 C11—7 D11—2 B12—4 C12—10 D12—8 F12—6 H12—4 J12—2 Z13—4 A13—2 B13—9 C13—10 D13—2 Z14—7 A14—3 B14—5 H14—3 Z15—3 A15—3 J15—2 *1972* 2G6—2 2I6—6 2DL—4 2D8—4 2H10—4 2V12—10 2B12—27 2F12—1 2D13—1 2A14—7 2J14—2 2V15—4 2X15—2

Phylum Annelida

Class Polychaeta

Ampharete acutifrons (Grube) *1971* G4—2 I5—2 A6—1 B6—1 D6—1 E6—3 F6—1 G6—9 H6—3 A8—4 B8—8 F8—5 H8—3 J8—8 H10—3 J10—2 B12—1 C12—3 D12—8 F12—1 J12—13 Z13—3 A13—5 B13—7 C13—9 Z14—10 A14—4 B14—4 H14—1 J14—10 Z15—7 A15—4 J15—6 *1972* 2G6—1 2I6—4 2DL—6 2H10—1 2B12—3 2A14—6 2J14—2
Ampharetidae sp. *1971* E6—1 F6—1 G6—3 Z15—2
Aonides oxycephala (Sars) *1972* 2A14—1
Aonides paucibranchiata Southern *1971* D12—1 B14—2 H14—1 B15—1 *1972* 2D13—1 2Z18—2
Aphrodite aculeata (L.) *1971* F8—1 H10—2 C13—1 J15—2 *1972* 2H10—1
Aphroditidae spp. *1971* H6—1 D12—1 J12—2 C13—1 J14—1 Z15—1 *1972* 2V12—2 2B12—4 2J14—1 2Z15—3
Aricidea minuta Southward *1971* F12—2 B14—2 *1972* 2I6—18 2DL—4 2V12—4 2B12—1 2F12—16 2U15—2 2V15—4 2Z15—1 2Z18—2 2G18—2
Autolytus sp. *1971* Z13—11 A13—1 Z14—1 A14—4 *1972* 2V12—2 2B12—1 2J14—4 2V15—2 2X15—6

Caesicirrus neglectus Arwidsson *1971* D3—2 F4—2 I5—6 A6—1 B6—2 C6—1 D6—1 E6—17 F6—12 G6—32 H6—2 A8—22 B8—1 D8—1 F8—59 H8—23 J8—8 H10—171 J10—2 C11—4 B12—1 J12—30 Z13—1 A13—1 B13—13 C13—2 D13—1 Z14—5 A14—14 B14—3 F14—2 H14—5 J14—105 Z15—17 A15—7 C15—1 D15—1 J15—134 *1972* 2B6—1 2G6—16 2I6—10 2DL—24 2D8—12 2H10—174 2F12—1 2D13—2 2A14—11 2J14—97 2Z15—7 2C15—1 2E17—2 2Z18—2 2G18—2
Capitella capitata (Fabricius) *1971* D3—4 D4—2 E4—1 F4—1 G4—4 H4—2 I5—1 A6—2 B6—4 D6—1 E6—4 F6—1 G6—9 H6—3 A8—2 A10—23 B10—1 F10—7 H10—1 B11—1 C12—1 D12—1 F12—6 H12—31 Z13—2 B14—1 H14—2 A15—3 J15—3 *1972* 2D4—1 2G6—1 2I6—10 2H10—1 2V12—2 2B12—3 2A14—2 2Z15—3
Capitellidae sp. *1971* C4—1 H14—1 D15—1
?*Capitomastus minimus* (Langerhans) *1971* D6—1 *1972* 2Z15—1
Caulleriella alata (Southern) *1971* H6—1 F8—1 A10—1 F10—1 C11—4 C12—2 D12—5 F12—6 J12—4 Z13—6 A13—14 B13—8 C13—26 Z14—19 A14—17 B14—10 D14—1 Z15—10 A15—6 J15—2 *1972* 2I6—12 2H10—3 2V12—12 2B12—13 2F12—4 2D13—1 2A14—2 2J14—1 2U15—2 2V15—2 2X15—2
Caulleriella ? *caput-esocis* (Saint-Joseph) *1791* B12—1 Z15—1
Caulleriella killariensis (Southern) *1971* D12—1
Caulleriella sp. *1971* F8—1 D12—1
Caulleriella zetlandica (McIntosh) *1971* Z14—1 Z15—3
Chaetozone setosa Southern *1971* C4—2 D4—5 E4—1 F4—3 G4—19 H4—18 I5—21 A6—5 B6—2 C6—35 D6—9 E6—4 F6—4 G6—5 H6—21 A8—3 B8—15 C8—5 D8—3 F8—1 H8—2 J8—1 A10—5 B10—19 C10—7 D10—13 F10—7 H10—1 J10—2 B11—3 C11—4 F12—22 H12—16 D13—1 Z14—2 B14—3 H14—2 A15—11 B15—3 C15—1 J15—2 *1972* 2B6—3 2G6—6 2I6—6 2DL—8 2D8—10 2C10—3 2H10—1 2B12—2 2F12—13 2D13—4 2U15—4 2V15—2 2C15—2 2E17—2 2Z18—16 2G18—2
Chone sp. *1971* J14—1 *1972* 2DL—2 2H10—1 2X15—2
Cirratulidae spp. *1971* H4—2 B8—1 J8—2 A10—1 B10—1 H10—3 C11—1 B12—1 D12—1 H12—1 Z13—1 C13—1 D14—1 Z15—2 A15—4 *1972* 2G6—1 2H10—1 2B12—2 2D13—1 2A14—2
Cirratulus cirratus (Müller) *1971* B12—3 D12—3 Z13—12 A13—3 B13—2 C13—1 Z14—2 *1972* 2G6—1 2A14—1 2Z15—1
Cirratulus filiformis Keferstein *1971* J10—1 C11—1 B12—1 C12—6 D12—2 F12—5 H12—1 J12—22 Z13—9 A13—2 B13—12 C13—23 D13—5 Z14—1479 A14—2088 B14—94 Z15—1 J15—1 *1972* 2H10—1 2V12—6 2B12—4 2D13—1
Cirriformia (Audouinia) ? *filigera* (Delle Chiaje) *1971* Z13—1 A13—1
Cirriformia (Audouinia) tentaculata (Montagu) *1971* C11—1 C12—8 D12—18 H12—1 A13—3 B13—5 C13—13 Z14—6 A14—1 B14—5 Z15—10 *1972* 2I6—12 2D8—1 2H10—1 2V12—6 2B12—81 2F12—2 2A14—7 2J14—1 2X15—4 2Z15—4
Clymene affinis Sars *1971* H10—7 J12—4 J14—6 Z15—1 J15—21 *1972* 2DL—16 2H10—25 2A14—2 2J14—10
Diplocirrus glaucus Haase *1971* G6—1 F8—1 H10—1 C13—1 *1972* 2G6—3 2H10—2 2J14—1 2Z15—1
Dorvillea (Staurocephalus) kefersteini (McIntosh) *1971* C13—1 *1972* 2I6—8 2V12—8 2B12—3 2A14—1
Ephesia gracilis Rathke *1972* 2A14—1
Eteone flava (Fabricius) *1971* A10—1 H10—1 J10—1 A13—1 B13—6 C13—1 Z14—11 A14—4 Z15—2 *1972* 2DL—2 2H10—1 2V12—2 2B12—2 2F12—1 2Z15—1
Eteone foliosa Quatrefages *1971* F4—1 G4—2 H4—1 A6—1 C6—1 E6—1 F6—1 G6—1 B10—1 F10—1 D12—1 B13—1 D13—1 J15—1 *1972* 2D8—1
Eteone longa (Fabricius) *1971* C4—2 F4—4 G4—2 H4—1 A6—1 B6—1 C6—1 D6—3 F6—1 G6—5 A8—3 B8—2 A10—2 B10—3 C10—3 H10—1 B11—1 C11—1 B12—1 H12—2 J12—1 Z13—1 A13—2 C13—3 H14—1 J14—2 Z15—1 A15—2 B15—1 *1972* 2C10—1 2H10—3 2V12—2 2B12—1 2D13—2 2J14—10
Eteone sp. *1971* B14—1 F14—2 J15—1 *1972* 2I6—2 2F12—1
Eulalia macroceros (Grube) *1971* A13—1 A14—1
Eulalia sp. *1972* 2A14—1
Eumida (Eulalia) sanguinea (Oersted) *1971* E4—1 F4—24 G4—17 H4—2 I5—2 A6—25 B6—10 C6—36 D6—2 E6—9 F6—1 H8—1 J8—2 A10—2 H10—1 C11—1 D12—3 F12—3 H12—1 J12—3 A13—1 B13—1 C13—6 Z14—4 A14—4 C14—2 H14—4 J14—2 A15—2 J15—4 *1972* 2G6—1 2I6—8 2DL—8 2H10—2 2B12—15 2V15—2 2Z18—2
Eunice harassii Audouin & Milne-Edwards *1971* A14—1 A15—1
Eusyllis blomstrandi Malmgren *1971* D6—1 H10—1 F12—2 J12—1 Z13—5 A13—9 B13—3 C13—1 D13—1 Z14—4 A14—5 B14—1 H14—1 A15—5 J15—1 *1972* 2I6—2 2V12—2 2B12—7 2J14—2 2Z15—3
Exogone gemmifera (Pagenstecher) *1971* J14—1 A15—1
Exogone hebes (Webster & Benedict) *1972* 2I6—6 2H10—2 2V12—2 2F12—1 2C15—1
Flabelligera affinis Sars *1972* 2A14—1
Gattyana cirrosa (Pallas) *1971* A13—12 B13—5 Z14—8 A14—5 B14—2 A15—4 J15—3 *1972* 2DL—2 2A14—1 2J14—1 2V15—2 2Z15—3
Glycera convoluta Keferstein *1971* H10—1 J10—1 B13—1 J15—1 *1972* 2V12—2 2V15—6
Glycera lapidum Quatrefages *1971* D11—2 C12—2 H12—1 Z13—7 A13—13 B13—4 C13—3 Z14—4 A14—1 B14—2 D14—2 F14—12 *1972* 2I6—2 2B12—2 2Z15—1 2Z18—4
Glycinde nordmanni (Malmgren) *1971* G4—1 F6—1 G6—1 B8—2 F8—2 H8—3 J8—2 B12—1 C12—1 D12—2 F12—1 H12—2 J12—1 A13—1 C13—2 H14—3 J14—1 A15—1 *1972* 2G6—1 2DL—2 2H10—1 2D13—1

Euclymene oerstedi (Claparède)

Goniada maculata Oersted *1971* F4—1 G6—1 A8—1 F8—1 F10—2 C11—1 F12—1 B13—1 Z15—1 A15—1 *1972* 2G6—2 2F12—1 2V15—6
Gyptis (*Oxydromus*) *capensis* (Day) B12—2 C12—2 D12—1 F12—1 Z14—2 A14—2 B14—1 H14—1 A15—1 *1972* 2H10—1 2V12—4 2B12—3 2F12—1 2D13—1 2A14—2 2J14—3 2Z15—1
Gyptis sp. *1971* A13—1
Halosydna gelatinosa (Sars) *1972* 2J14—1
Harmothoë imbricata (L.) *1971* I5—1 B11—1
Harmothoë ljungmani (Malmgren) *1971* C6—1 J15—1
Harmothoë lunulata (Delle Chiaje) *1971* G4—1 I5—1 A6—1 E6—1 G6—1 C13—2 A14—1 Z15—2 J15—1 *1972* 2H10—1 2A14—1 2J14—1
Harmothoë sp. *1972* 2V15—2 2X15—2
Harmothoë spinfera/extenuata *1971* A10—1 J12—1 Z13—3 A13—3 B13—2 C13—5 Z14—4 A14—12 Z15—3 A15—2 *1972* 2J14—1
Hesionidae sp. *1972* 2I6—2
Hydroides norvegica Gunnerus *1971* C13—1
Jasmineira elegans Saint-Joseph *1971* Z13—1 A13—1 B13—1
Kefersteinia cirrata (Keferstein) *1971* Z13—1 A13—4 Z14—1 A14—1
Lanice conchilega (Pallas) *1971* D3—16 C4—4 D4—3 E4—2 F4—5 G4—15 H4—13 I5—16 A6—6 B6—5 C6—4 D6—10 E6—18 F6—9 H6—4 A8—1 B8—1 C8—2 F8—1 J8—1 H10—7 B11—4 C11—19 D11—1 C12—1 J12—1 Z13—5 A13—9 B13—30 C13—38 D13—3 Z14—?3 A14—5 B14—4 H14—3 J14—8 Z15—18 A15—51 J15—168 *1972* 2D4—13 2B6—29 2G6—8 2I6—166 2DL—42 2D8—8 2H10—40 2V12—36 2B12—388 2J14—14 2V15—14 2X15—2 2Z15—23
Laonice cirrata (Sars) *1971* Z13—2 A13—1
Leiochone johnstoni Saint-Joseph *1971* J15—1 *1972* 2DL—12 2J14—5
Lepidonotus clava (Montagu) *1972* 2G6—1
Lepidonotus squamatus (L.) *1971* Z13—1 Z15—1 *1972* 2V12—2
Lumbrineris gracilis Ehlers *1971* I5—1 H6—1 C11—2 F12—1 J12—2 B13—2 C13—1 Z14—3 A14—3 B14—1 H14—2 J14—4 Z15—3 A15—2 B15—2 J15—4 *1972* 2G6—1 2H10—3 2V12—10 2B12—2 2D13—2 2A14—3 2J14—8 2U15—4 2V15—4 2X15—2 2Z15—4 2E17—4 2Z18—10
Lumbrineris latreilli (Audouin & Milne-Edwards) *1972* 2B12—1
Magelona mirabilis (Johnston) *1971* D3—1 C4—1 D4—6 E4—5 F4—23 G4—26 H4—29 I5—9 A6—6 B6—8 C6—27 D6—3 H6—1 B8—8 C8—15 D8—8 F8—1 J8—9 A10—12 B10—63 C10—62 D10—47 F10—65 J10—3 B11—3 C11—1 D11—1 H12—1 *1972* 2D4—1 2B6—5 2G6—1 2D8—11 2C10—35 2Z15—1 2E17—2 2G18—2
Malacoceros (*Scolelepis*) *ciliata/girardi* *1971* Z13—10 A13—10 B13—7 C13—3 Z14—5 A14—5 Z15—5 A15—2 *1972* 2I6—2 2B12—7 2Z15—1
Maldanidae sp. *1971* H6—3
Mediomastus fragilis Rasmussen *1971* E6—2 F6—1 G6—8 H6—11 A8—1 B8—1 F8—1 A10—1 H10—1 C11—20 B12—16 C12—59 D12—52 F12—10 H12—7 J12—20 Z13—86 A13—53 B13—100 C13—153 D13—5 Z14—138 A14—97 B14—71 C14—2 F14—1 H14—8 J14—10 Z15—44 A15—44 B15—1 C15—1 J15—45 *1972* 2G6—1 2I6—56 2DL—2 2H10—7 2V12—254 2B12—23 2F12—4 2D13—10 2A14—90 2J14—45 2U15—4 2V15—42 2X15—8 2Z15—18
Melinna cristata (Sars) *1971* J12—6 Z13—5 A13—8 B13—4 Z14—1 A14—1 B14—1 *1972* 2V12—2 2A14—2
Melinna palmata Grube *1971* E6—1 G6—2 H6—1 A8—11 B8—1 F8—1 H10—2 F12—1 A13—2 B13—10 C13—1 Z14—3 B14—1 *1972* 2G6—6 2DL—8 2H10—5 2F12—1 2A14—1 2J14—1
Microphthalmus similis Bobrezky *1971* C15—6
Myriochele sp. *1971* E4—6 F4—9 G4—23 H4—3 I5—9 A6—1 C6—4 D6—5 E6—35 F6—32 G6—81 H6—48 A8—67 B8—17 C8—1 D8—3 F8—8 H8—52 J8—93 B10—1 C10—1 F10—20 H10—82 J10—53 C11—8 D11—3 D12—1 F12—3 H12—1 J12—27 Z13—1 B13—1 C13—2 Z14—1 A14—3 B14—2 J14—1 Z15—1 A15—7 J15—1 *1972* 2B6—2 2G6—230 2I6—36 2DL—770 2D8—27 2C10—1 2H10—143 2V12—58 2F12—2 2D13—1 2A14—4 2J14—10 2U15—4 2V15—24 2X15—2 2Z15—6 2E17—2 2Z18—4 2G18—2
Mystides limbata Saint-Joseph *1971* F4—1
Neoamphitrite figulus Dalyell *1971* D12—1 *1972* 2DL—2
Nephtys caeca (Fabricius) *1971* H6—1 C10—1 H14—1 J14—2 A15—1 *1972* 2G6—1 2I6—2 2DL—2 2B12—5 2X15—2
Nephtys ciliata (Müller) *1971* C12—1 J12—3 Z13—3 Z14—4 A14—9 Z15—2 A15—1 *1972* 2A14—1
Nephtys cirrosa Ehlers *1971* H6—1 A8—3 B10—8 C10—8 D10—6 B11—8 D11—2 B12—1 D13—1 B14—2 F14—3 Z15—1 B15—4 C15—2 D15—1 *1972* 2C10—28 2D13—12 2U15—2 2C15—6 2E17—6 2Z18—4 2G18—4
Nephtys hombergii Savigny *1971* D3—21 C4—8 D4—15 E4—5 F4—11 G4—11 H4—14 I5—10 A6—15 B6—7 C6—14 D6—10 E6—13 F6—20 G6—10 H6—6 A8—7 B8—6 C8—15 D8—13 F8—6 H8—10 J8—11 A10—4 B10—3 D10—1 F10—16 H10—25 J10—3 C11—7 D11—1 B12—2 D12—1 F10—10 H12—14 J12—2 A13—1 B13—1 B14—3 F14—1 H14—2 J14—10 Z15—6 A15—6 C15—1 J15—11 *1972* 2D4—9 2B6—3 2G6—3 2DL—2 2D8—1 2H10—13 2B12—1 2F12—1 2J14—9 2V15—2 2Z15—3 2Z18—2 2G18—2
Nephtys longosetosa (Oersted) *1971* E4—3 A8—3 B8—3 H8—1 A10—2 B10—2 C10—5 H10—4 C11—1 B11—1 B12—1 J12—2 F14—1 H14—1 J14—1 A15—1 B15—4 D15—1 J15—1 *1972* 2I6—2 2C10—1 2F12—2 2D13—1
Nephtys sp. *1971* B6—1 A10—1 J15—1

Nephtys sp. (juv.) *1971* D4—7 E4—1 F4—6 G4—2 H4—1 B6—4 D6—1 G6—5 H6—2 A8—5 B8—5 F8—8 A10—4 B10—10 C10—6 D10—2 B11—2 C11—1 D11—6 B12—1 H12—2 J12—1 C13—2 D13—1 B14—3 D14—1 H14—1 J14—1 C15—2 J15—1 *1972* 2G6—3 2H10—3 2F12—1 2D13—1 2Z15—2 2C15—1
Nereimyra punctata (Müller) *1971* D12—?1 B13—1 A14—1
Nereis sp. (juv.) *1971* A13—1 C13—1 *1972* 2DL—2 2A14—1
Nereis spp.* *1971* D6—1 F6—1 G6—1 B8—1 H8—1 J8—1 H10—1 B12—1 D12—5 Z13—2 B13—2 D13—1 Z14—4 A14—4 J14—1 Z15—3 A15—3 *1972* 2B12—2 2A14—1 2J14—1
Nicolea venustula (Montagu) *1971* A13—1 *1972* 2A14—3
Nicomache maculata Arwidsson *1971* H8—2 J8—1 J10—1 J12—1 H14—1 J14—13 J15—7 *1972* 2J14—4 2C15—1
Notocirrus scoticus (McIntosh) *1971* H14—2 J15—1
Notomastus latericius Sars *1971* D3—5 D4—7 F4—2 G4—1 A6—2 B6—1 E6—1 F6—2 H6—2 A8—12 B8—3 F8—1 A10—2 H10—2 J10—1 C11—1 B12—8 C12—10 D12—6 F12—2 H12—1 J12—3 B13—3 C13—8 Z14—6 A14—2 B14—2 J14—5 Z15—3 A15—1 J15—1 *1972* 2D4—1 2V12—2 2B12—2 2D13—1 2A14—3 2Z15—1 2E17—2
Ophelia borealis Quatrefages *1971* D11—1 F14—5 B15—2 C15—1 D15—2 *1972* 2C15—1
Ophelina acuminata Oersted *1971* H10—1 A13—1 B13—5 C13—1 D13—3 B14—5 J14—1 Z15—5 A15—3 J15—3 *1972* 2V12—2 2J14—4 2Z15—1
Ophiodromus flexuosus (Delle Chiaje) *1971* E6—1 F8—1 A14—1
Orbinia (*Aricea*) *cuvieri* (Audouin & Milne-Edwards) *1971* D14—2 F14—1 D15—2
Owenia fusiformis (Delle Chiaje) *1971* I5—5 H4—7 C6—1 E6—1 F6—2 G6—3 H6—3 A8—3 B8—1 F8—3 H8—3 J8—1 H10—1 J10—2 B11—1 B12—1 F12—3 H12—1 J12—2 Z13—5 A13—6 C13—3 D13—1 Z14—9 A14—6 B14—2 J14—7 Z15—15 A15—28 B15—1 D15—1 J15—16 *1972* 2B6—2 2G6—5 2I6—2 2DL—4 2H10—10 2V12—8 2B12—13 2F12—2 2D13—2 2A14—3 2J14—1 2V15—4 2Z15—5 2E17—2
Paraonis lyra Southern *1971* D13—1 D14—1 F14—1 C15—1 *1972* 2C15—1
Pectinaria auricoma (Müller) *1971* A8—1 A10—1 C12—1 D12—2 J12—3 B13—1 D13—1 A14—1 J14—2 Z15—1 J15—1 *1972* 2V12—2 2J14—1
Pectinaria koreni (Malmgren) *1971* D3—1 G4—1 I5—2 B6—1 E6—1 B8—1 F8—1 A10—6 C12—2 D12—3 B13—2 D13—1 Z14—1 J14—2 Z15—2 A15—1 J15—2 *1972* 2G6—1 2B12—1 2F12—1 2J14—1 2V15—6 2X15—8 2Z15—2
Pholoë minuta (Fabricius) *1971* E6—2 G6—2 H6—1 F8—1 H10—3 B12—1 C12—4 D12—1 J12—1 Z13—9 A13—6 B13—7 C13—11 Z14—6 A14—9 B14—2 Z15—1 A15—2 J15—1 *1972* 2G6—1 2I6—6 2DL—4 2D8—3 2H10—3 2V12—10 2B12—22 2F12—2 2A14—16 2J14—20 2V15—4 2Z15—6 2Z18—2
**Phyllodoce* (*Anaitides*) *maculata* (L.) *1971* C11—6 D11—1 Z13—3 B13—5 C13—7 Z14—2 A14—2 B14—1 Z15—2 A15—7 J15—17 *1972* 2B6—1 2G6—2 2I6—10 2DL—2 2H10—1 2B12—6 2V15—2 2Z15—2
**Phyllodoce* (*Anaitides*) *mucosa* Oersted *1971* D3—3 F4—1 I5—6 C6—2 E6—5 G6—5 A8—4 F8—1 J8—3 H10—1 C12—1 J12—2 B13—4 C13—4 D13—1 Z14—1 B14—1 Z15—4 J15—20 *1972* 2D4—4 2B6—3 2G6—3 2I6—4 2V12—4 2B12—10 2A14—5 2J14—71 2V15—2 2C15—1
Phyllodoce sp. w (white) *1971* C6—2 B8—1 H10—1 D15—1 *1972* 2I6—2 2E17—2
Phyllodoce sp. r/b (red/brown) *1971* C11—2
Phyllodocidae spp. *1971* G4—2 H4—1 F6—1 G6—1 J8—1 A10—1 F10—1 B11—1 C12—2 D15—1 *1972* 2E17—2
Pisione (*Praegeria*) *remota* (Southern) *1971* D11—1 C15—6
Pista cristata (Müller) *1972* 2I6—2
Poecilochaetus serpens Allen *1971* A10—1 H10—6 C11—1 D12—1 F12—18 H12—7 C13—1 Z14—1 A14—1 H14—4 J14—1 Z15—1 A15—1 J15—4 *1972* 2DL—2 2H10—2 2B12—2 2F12—6 2D13—1 2J14—1
Polycirrus sp. *1971* H6—3 H10—2 C11—62 D11—17 C12—1 F12—2 J12—1 Z13—5 A13—11 B13—6 C13—8 D13—39 Z14—?4 A14—1 B14—11 C14—36 D14—30 F14—38 Z15—3 A15—1 B15—6 C15—19 D15—4 J15—1 *1972* 2I6—10 2H10—1 2V12—2 2B12—1 2F12—1 2D13—5 2A14—6 2J14—3 2C15—3 2E17—2 2Z18—2 2G18—2
Polydora caulleryi Mesnil *1971* Z13—12 A13—7 B13—7 C13—17 Z14—33 A14—15 Z15—1 *1972* 2B12—1 2D13—1 2A14—4
Polydora ciliata (Johnston) *1971* Z13—10
Pomatoceros triqueter (L.) *1971* C12—1 D12—3 J12—8 Z13—9 A13—2 C13—2 Z14—7 J14—1 *1972* 2I6—8 2H10—1 2V12—4 2B12—26 2D13—1 2A14—15
Prionospio malmgreni Claparède *1971* D3—3 D4—3 E4—3 F4—4 G4—2 C6—2 D6—2 E6—60 F6—49 G6—74 H6—4 A8—7 B8—14 D8—1 F8—52 H8—4 J8—7 A10—1 F10—13 H10—37 J10—2 D12—4 F12—67 H12—117 J12—3 J14—2 J15—1 *1972* 2G6—18 2I6—4 2DL—2 2D8—8 2H10—17 2V12—2 2F12—18 2J14—4 2V15—2
Pseudopolydora pulchra (Carazzi) *1971* G4—3 I5—1 G6—1 Z13—2 A13—2 B13—2 Z14—9 A14—10 B14—2 Z15—7 J15—9 *1972* 2D4—1 2B6—2 2I6—2 2DL—6 2H10—6 2J14—2
Pygospio elegans (Claparède) *1971* D3—2
Sabella penicillus L. *1971* J12—1 J14—1 *1972* 2V15—2 2Z15—1
Sabellaria spinulosa Leuckart *1971* B12—1 J12—32 Z13—5
Sabellidae spp. *1971* F8—1 B12—1 D12—1 A14—1

* *N. pelagica* L. with *N. longissima* Johnston
* computed together, as *Phyllodoce* spp.

Scalibregma inflatum Rathke *1971* C11—1 C12—4 D12—2 F12—1 Z13—7 A13—4 B13—16 C13—12 Z14—18 A14—13 B13—3 D14—1 Z15—25 A15—1 J15—2 *1972* 2V2—16 2B12—1 2A14—3 2J14—22 2V15—8 2X15—4 2Z15—1

Scalisetosus pellucidus (Ehlers) *1971* Z14—1 *1972* 2A14—1 2J14—1

Scolelepis (*Nerine*) sp. *1971* B10—2 B11—7 *1972* 2C10—3 2E17—2

Scolelepis squamata (Müller) *1971* D11—1

Scoloplos armiger (Müller) *1971* D3—6 D4—13 E4—1 H4—1 A6—9 B6—2 H6—1 A8—8 B8—2 J8—1 A10—8 B10—2 C10—1 F10—1 B11—1 C11—3 D11—2 B12—11 C12—53 D12—30 F12—1 J12—14 Z13—10 A13—13 B13—25 C13—49 D13—7 Z14—41 A14—18 B14—28 C14—2 D14—5 F14—7 H14—2 J14—12 Z15—10 A15—3 B15—3 C15—2 D15—7 J15—6 *1972* 2B6—6 2I6—8 2DL—4 2H10—1 2V12—18 2B12—15 2F12—2 2D13—4 2A14—43 2J14—1 2Z15—2 2C15—5 2E17—2 2Z18—24 2G18—30

Serpulidae sp. *1971* J14—1

Sigalion mathildae Audouin & Milne-Edwards *1971* D3—11 C4—1 D4—1 E4—2 F4—2 G4—2 H4—4 I5—2 A6—3 B6—4 C6—2 E6—1 G6—1 H6—2 A8—5 B8—2 D8—3 F8—1 J8—2 B10—1 C10—1 D10—1 F10—2 *1972* 2B6—1 2G6—5 2DL—4 2D8—3 2C10—3 2F12—4 2E17—8

Sphaerosyllis bulbosa Southern *1971* Z13—1 *1972* 2B12—?1

Spio filicornis (Müller) *1971* C4—9 D4—4 E4—2 F4—10 G4—3 H4—16 I5—5 A6—2 C6—4 D6—1 E6—14 F6—6 G6—5 H6—3 A8—1 B8—2 C8—3 F8—2 J8—4 A10—6 B10—5 C10—4 D10—1 F10—9 H10—6 B11—1 C11—1 F12—7 H12—8 J12—1 Z13—26 A13—13 B13—14 C13—7 Z14—22 A14—24 B14—1 J14—1 Z15—16 A15—5 D15—2 J15—21 *1972* 2D4—3 2B6—9 2I6—4 2DL—2 2D8—1 2C10—4 2H10—9 2B12—8 2F12—3 2A14—1 2J14—6 2Z15—2 2Z18—2 2G18—2

Spio sp.* *1971* Z13—9 A13—7 B13—2 C13—2 Z14—1 D15—4 *1972* 2Z15—1 2C15—26 2G18—14

Spionidae spp. *1971* J8—1 A10—1 H10—1 Z13—1 A13—1 Z14—4 J14—2 Z15—1 C15—1 *1972* 2H10—1 2B12—1 2A14—1 2X15—2 2Z18—2

Spiophanes bombyx (Claparède) *1971* D3—5 C4—2 D4—3 E4—7 F4—18 G4—28 H4—29 I5—14 A6—5 B6—11 C6—8 D6—13 E6—13 F6—17 G6—21 H6—13 A8—6 B8—22 C8—5 D8—3 F8—7 H8—2 J8—6 A10—10 B10—3 C10—7 D10—6 F10—1 H10—16 J10—1 F12—3 H12—4 J12—1 D13—1 D14—1 F14—1 H14—5 J14—5 B15—1 J15—14 *1972* 2D4—1 2B6—14 2G6—21 2DL—12 2D8—15 2C10—4 2H10—28 2B12—3 2F12—12 2D13—2 2A14—1 2J14—12 2U15—6 2V15—4 2Z15—3 2Z18—12 2G18—18

Sthenelais boa (Johnston) *1971* I5—1 H6—2 H10—1 B12—1 C12—4 D12—7 J12—1 A13—1 B13—3 C13—4 Z14—2 A14—1 B14—3 Z15—14 A15—6 J15—1 *1972* 2V12—2 2B12—2 2Z15—8

Sthenelais limicola (Ehlers) *1971* D6—2 E6—2 F6—2 G6—2 A8—1 C8—1 D8—1 H10—1 J10—1 C11—1 D11—1 A15—2 D15—1 J15—8 *1972* 2D4—3 2G6—4 2DL—2 2D8—5 2H10—2 2B12—1 2F12—1 2J14—10 2U15—2 2G18—2

Stylaroides plumosa (Müller) *1971* Z14—1

Syllidae spp. *1971* J15—2 *1972* 2B12—1

Syllidia armata Quatrefages *1971* B13—1 Z14—1 ?A14—1

Syllis amica Quatrefages *1972* 2I6—4

Terebellidae spp. *1971* H6—1 B12—1 D12—1 J12—1 A13—2 B13—1 A14—1 *1972* 2Z15—1

Terebellides stroemi Sars *1971* H8—1 *1972* 2G6—1 2DL—2 2B12—1

Tharyx marioni (Saint-Joseph) *1971* B6—1 H10—5 D11—3 J12—1 Z13—3 A13—1 B14—1 J14—2 Z15—2 *1972* 2B6—1 2G6—7 2I6—6 2DL—112 2H10—2 2V12—2 2J14—2

Thelepus sp. *1971* D6—1

Travisia forbesii Johnston *1971* D13—8 D15—1 *1972* 2D13—6 2C15—1 2G18—12

Class Oligochaeta

Oligochaeta sp. *1971* F12—4 H12—8 H14—2 *1972* 2I6—2 2F12—9 2J14—1 2Z15—1

Peloscolex benedeni Udekem *1971* A10—3 F10—3 C11—2 B12—124 C12—117 D12—59 Z13—10 A13—21 B13—4 C13—3 Z14—4 H14—1 Z15—2 *1972* 2D4—2 2V12—8 2B12—67 2F12—5 2D13—2 2A14—3

Phylum Sipunculoidea

Phascolion strombi (Montagu) *1971* J12—1

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*Ventral hooks not before 17th setiger.

Phylum Priapuloidea

Priapulus caudatus Lamark *1971* B13—2 C13—1 Z14—1 *1972* 2V12—2 2J14—1

Other 'Vermes'

Vermes spp. *1972* 2I6—2 2A14—2

Phylum Arthropoda

Sub-Phylum Crustacea

Class Ostracoda

Cylindroleberis mariae (Baird) *1971* G6—1 F14—1 *1972* 2DL—8

Class Copeoda

Anomalocera patersoni Templeton *1971* C6—1

Class Cirripedia

Balanus balanus (L.) *1971* J12—1 *1972* 2J14—1

Balanus crenatus Bruguière *1971* J12—10 Z13—4 B13—100 A14—16 J15—59 *1972* 2D4—43 2B12—110 2A14—1 2J14—30

Verruca stroemia (Müller) *1972* 2A14—4

Class Malacostraca

Ampelisca brevicornis (Costa) *1971* C4—4 E4—7 F4—5 G4—8 H4—5 I5—47 A6—2 B6—1 C6—3 E6—10 F6—9 G6—12 H6—2 A8—38 B8—36 C8—1 F8—12 J8—7 A10—5 H10—15 C11—2 H12—1 J12—1 J14—10 J15—20 *1972* 2B6—1 2G6—50 2DL—8 2H10—5 2F12—1 2J14—6

Ampelisca diadema/tenuicornis *1971* J8—2 C12—3 D12—7 J12—20 Z13—125 A13—172 B13—54 C13—35 Z14—33 A14—56 B14—2 Z15—11 A15—1 *1972* 2H10—1 2B12—25 2D13—3 2A14—18 2Z15—1

Ampelisca sp. *1972* 2I6—6

Ampelisca spinipes Boek *1971* H10—1 C11—2 C12—1 D12—4 J12—2 Z13—1 A13—7 B13—15 C13—6 Z14—1 B14—3 D14—1 H14—2 J14—17 Z15—2 A15—7 J15—22 *1972* 2H10—1 2V12—18 2B12—29 2V15—8 2Z15—1

Ampelisca typica Krøyer *1971* H6—1

Amphilochus manudens Bate *1971* A13—2 A14—1

Amphilochus neopolitanus Della Valle *1972* 2A14—1

Amphilochus sp. *1971* J15—2

Amphilochus spence-batei (Stebbing) *1971* A13—3 Z14—2 Z15—3 A15—1 *1972* 2H10—1 2B12—3 2X15—2

Amphipoda spp. *1971* A8—1 B13—1 F14—1 A15—1 J15—3 *1972* 2I6—2 2V12—2 2B12—5 2A14—1 2V15—4 2Z15—1

Anapagurus hyndmani (Bell) *1971* Z13—1 A13—1 A14—8

Anapagurus laevis (Bell) *1972* 2U15—4

Aora typica Krøyer *1971* I5—1 B11—1 Z13—7 A13—3 A14—5 A15—1 *1972* 2A14—2

Bathyporeia elegans Watkin *1971* E4—1 G4—2 A10—2 B10—9 C10—2 D10—3 B11—6 D11—1 F14—1 B15—1 C15—2 *1972* 2C10—6 2U15—2 2Z18—6 2G18—6

Bathyporeia nana Toulmond *1972* 2C10—3

Bathyporeia tenuipes Meinert *1971* E4—2 H4—1 I5—2 C6—1 H6—2 C8—1 A10—1 B10—1 C10—3 D10—3 A15—1 *1972* 2D4—1 2D8—1 2C10—4 2F12—2 2U15—8 2E17—2

Bodotria arenosa Goodsir *1971* G4—1 B15—1 *1972* 2G6—1 2I6—2

Bodotria scorpioides (Montagu) *1971* Z13—2 A13—4 A14—1 A15—2 B15—1 J15—1 *1972* 2DL—2 2V12—4 2B12—8

Caprellidae spp. *1971* F4—1 G4—13 E6—9 G6—5 A8—1 B10—1 H10—2 C11—2 H12—5 C13—1 H14—1 A15—1 J15—2 *1972* 2B6—4 2G6—12 2I6—2 2DL—2 2D8—1

Cheirocratus sundevalli (Rathke) *1971* D12—2 A13—1 C13—1 B14—1 *1972* 2U15—2

Corophium bonelli Milne-Edwards *1971* D11—1 Z13—41 A13—4 B13—2 Z14—10 A14—5 *1972* 2G6—1 2DL—2 2B12—3 2Z15—1

Corophium crassicorne Bruzelius *1971* H6—8 C11—2 D12—1 Z13—1 *1972* 2V12—6 2B12—9

Corystes cassivelaunus (Pennant) *1971* H4—1 I5—2 D8—1 F8—1 H8—1 H10—1 H12—1 *1972* 2B6—1 2G6—2 2F12—2 2J14—1

Crangon crangon (L.) *1971* C4—1 *1972* 2I6—2

Cumacea spp. *1971* C6—1 H6—1 C13—1

Diastylis bradyi Norman *1971* D4—1 F4—1 G4—1 H4—3 G6—1 B8—3 C8—1 A10—4 C10—3 D10—2 B11—1 C11—3 B12—2 F14—2 H14—1 B15—4 D15—1 *1972* 2D4—3 2D8—1 2C10—4 2C15—2 2E17—2 2Z18—2

Diastylis laevis Norman *1971* J15—1

Diastylis lucifera Krøyer *1971* C4—1 F4—3 G4—2 H4—1 H6—2 C8—1 D8—2 F8—1 B10—3 C10—6 C11—1 D14—1 A15—2 *1972* 2B6—1 2I6—8 2DL—76 2C10—1 2V12—2 2B12—1

Erichthonius brasiliensis Dana *1971* Z13—29 A13—2 Z14—2 A14—9 Z15—5 A15—1 J15—6 *1972* 2X15—4

Eudorella truncatula (Bate) *1971* G6—2 J8—1 H10—3 J15—3 *1972* 2H10—1 2B12—1 2A14—1 2J14—6 2Z15—1 2G18—2

Eudorellopsis deformis (Krøyer) *1971* H6—1

Eurydice spinigera Hansen *1971* C11—1

Eurynome aspera (Pennant) *1971* B11—4 Z13—3 A13—1 A14—2

Gastrosaccus spinifer (Goes) *1971* D15—1

Gnathia ? oxyuraea (Lilljeborg) *1971* Z13—2 C13—1 *1972* 2G6—1 2DL—4

Harpinia antennaria Meinert *1971* E4—3 H4—1 E6—5 F6—2 G6—12 H6—3 F8—10 H8—5 J8—1 H10—18 C12—1 D12—2 F12—1 J12—1 A13—7 B13—1 C13—19 B14—3 J14—14 Z15—12 A15—9 J15—28 *1972* 2G6—12 2I6—2 2DL—2 2D8—1 2H10—20 2V12—2 2J14—40 2V15—2 2X15—4 2Z15—18

Harpinia crenulata (Boek) *1971* H10—3 J15—1 *1972* 2H10—1 2J14—2

Harpinia ? pectinata Sars *1972* 2A14—3

Hippomedon denticulatus (Bate) *1971* C4—1 H4—1 C6—3 A10—1 D11—1 *1972* 2B6—1 2I6—4 2C10—1 2F12—1 2D13—1 2Z18—2

Hyas araneus (L.) *1971* Z13—1 Z15—1 *1972* 2Z15—1

Hyas coarctatus Leach *1971* C13—1 A14—1 J15—1 *1972* 2X15—2

Iphinoë trispinosa (Goodsir) *1971* C4—4 E4—1 G4—5 H4—28 B6—1 H6—2 A10—21 B10—12 C10—3 *1972* 2B6—1 2I6—2

Lysianassa ceratina (Walker) *1971* Z13—1

Lysianassidae spp. *1971* A13—1 *1972* 2A14—1

Macropipus (Portunus) depurator (L.) *1972* 2B12—1 2D13—1

Macropipus (Portunus) holsatus (Fabricius) *1971* D6—1 B11—2 C11—1 B12—1 A13—1 A15—1 J15—2 *1972* 2D4—1

Macropipus (Portunus) pusillus (Leach) *1971* C12—1 Z13—1 B13—1 C13—1 Z14—1 *1972* 2A14—1 2J14—1 2V15—4 2X15—2 2Z15—1

Macropodia rostrata (L.) *1972* 2Z15—1

Majidae sp. *1972* 2A14—1

Megalopa larva *1971* C11—1 D11—1 C12—1 A13—3 Z14—1

Megaluropus agilis Hock *1971* H4—3 A10—1 C10—3 C11—1 F14—1 *1972* 2I6—2 2C15—1

Megamphopus cornutus Norman *1971* Z13—3 A13—1 B13—1 C13—2

Megamphopus sp. *1972* 2I6—2

Melita obtusata (Montagu) *1971* B11—1 C11—4 J12—1 A13—6 B13—2 Z14—5 A15—4 J15—3 *1972* 2V12—2 2B12—25 2F12—1 2Z15—4

Microprotopus maculatus Norman *1971* F4—1

Mysidae sp. *1971* A13—1

Nototropis (Atylus) falcatus (Metzger) *1971* D14—4 C15—2 *1972* 2G6—1 2I6—2 2F12—2 2D13—2 2C15—1

Nototropis (Atylus) swammerdami (Milne-Edwards) *1971* D3—1 E6—1 B10—2 C12—1 J15—1 *1972* 2B6—8 2DL—2 2C10—3 2B12—3 2E17—2

Nototropis (Atylus) vedlomensis (Bate & Westwood) *1971* J12—2 C13—3 A14—1 H14—1 A15—1 *1972* 2Z15—2

Orchomenella nana (Krøyer) *1971* C4—1 C8—1 D12—1 B13—1 C13—1 Z14—1 Z15—1 *1972* 2I6—2 2H10—8 2V12—2 2A14—1 2Z15—1

Orchomenella sp. *1971* D10—1

Pagurus bernhardus (L.) *1971* D6—1 G6—1 J12—1 B13—1 *1972* 2D4—1 2DL—2 2B12—3 2D13—1 2A14—2 2J14—2 2V15—2

Pagurus cuanensis Bell *1971* B13—1

Pagurus sp. (? juv.) *1971* Z13—3 A13—2 A15—1

Pandalina brevirostris (Rathke) *1971* J12—1

Pandalus montagui Leach *1971* A13—1

Perioculodes longimanus (Bate & Westwood) *1971* G4—4 C6—2 H6—2 B10—3 C10—4 D10—1 H14—1 C15—1 *1972* 2B6—2 2F12—2 2D13—1

Photis longicaudata (Bate & Westwood) *1971* D6—1 F6—10 G6—1 H10—2 J12—10 Z13—25 A13—42 B13—12 C13—26 D13—2 Z14—39 A14—39 B14—1 F14—1 J14—2 Z15—65 A15—4 J15—60 *1972* 2G6—1 2I6—2 2H10—11 2V12—76 2B12—9 2D13—1 2A14—43 2J14—6 2X15—38 2Z15—24

Photis pollex Walker *1971* C6—1 H10—2 B11—1 Z13—5 A13—10 B13—2 B14—1 J14—1 Z15—2 A15—1 J15—1 *1972* 2H10—1 2V12—6 2B12—6 2A14—1 2Z15—2

Pontocrates altamarinus (Bate) *1971* B10—3 C10—4 D11—1 *1972* 2Z15—2 2E17—2

Pontocrates arenarius (Bate) *1971* A10—1 *1972* 2C10—2 2F12—1 2U15—2

Pontocrates sp. *1971* B10—1.

Porcellana longicornis (L.) *1971* J12—2 Z13—1 A14—1 *1972* 2A14—3

Pseudocuma gilsoni Bacescu *1971* D15—1 *1972* 2Z18—2

Siphonoecetes sp. *1971* G4—1 H4—1 H6—2 B10—1 D15—1 *1972* 2X15—2 2E17—2

Stenothoë marina (Bate) *1971* B11—1 C11—1 Z13—2 A13—1 C13—2 A14—2 Z15—4 *1972* 2V12—2 2A14—1 2X15—2 2Z15—1

Stenothoë monoculoides (Montagu) *1971* F12—1

Stenothoë sp. *1971* H10—1

Synchelidium maculatum Stebbing *1971* C4—1 E4—1 F4—4 G4—3 H4—6 A6—1 C6—1 D6—1 G6—1 H6—3 A10—5 B10—4 C10—2 D10—1 H10—1 B11—3 C11—1 D11—2 B12—1 F12—3 B14—2 H14—1 A15—1 B15—3 D15—1 J15—1 *1972* 2D4—3 2I6—4 2H10—1 2B12—2 2F12—2 2J14—1 2U15—4 2C15—1 2E17—4

Tanaidacea sp. *1971* E6—1 H6—1 H10—1 D12—1 F12—1 Z13—1 A13—1 C13—4 Z15—2 A15—2 J15—2 *1972* 2G6—2 2I6—10 2H10—1 2V12—6 2J14—1 2V15—2 2Z15—4

Unciola planipes Norman *1971* F14—1 D15—1

Urothoë elegans Bate *1971* F6—3 H6—21 A10—1 C11—31 D11—1 D12—3 F12—1 A13—3 C13—1 D13—3 B14—16 D14—1 J14—2 Z15—1 A15—1 B15—1 J15—11 *1972* 2G6—2 2I6—486 2DL—26 2D8—1 2V12—10 2B12—63 2F12—4 2D13—6 2U15—8 2V15—2 2X15—2 2Z15—4 2Z18—6

Sub-Phylum Pycnogonida

Anoplodactylus petiolatus (Krøyer) *1971* H6—2 D12—1 J12—1 Z13—26 A13—10 A14—1 Z15—2 A15—1 *1972* 2D4—1 2B6—1 2V12—4 2B12—6 2V15—2 2Z15—4 2Z18—2

Nymphon ?gracile Leach *1971* D12—1

*Nymphon rubrum** Hodge *1971* B11—1 C11—1 Z13—3 A13—8 + ?1** B13—1 Z14—2 Z15—2 A15—4 *1972* 2B6—1 2I6—2 2DL—2 2H10—1 2V12—10 2B12—8 2A14—3 2J14—1 2V15—2 2X15—2 2Z15—1

Pycnogonida spp. *1971* F12—1 A14—1 *1972* 2C10—1 2V12—4 2B12—1

Pycnogonum littorale (Ström) *1971* A15—1

Phylum Mollusca

Class Polyplacophora

Lepidopleurus asellus (Gmelin) *1971* Z14—1

Class Gastropoda

Buccinum undatum L. *1971* B13—1

Capulus ungaricus (L.) *1971* A14—1

Eubranchus sp. *1972* 2Z15—5

Natica alderi Forbes *1971* F4—2 G4—1 D6—1 E6—1 G6—1 H6—2 C8—1 D8—2 H8—1 A10—2 D10—1 B12—1 C12—1 F12—2 Z13—3 A13—2 B13—2 Z14—1 A14—4 J14—5 Z15—6 A15—2 B15—1 J15—2 *1972* 2G6—1 2DL—6 2B12—1 2F12—1 2A14—1 2E17—2

Natica catena (Da Costa) *1971* F8—1

Philine aperta Pruvot-Fol *1971* I5—1 E6—2 D8—1 F8—1 J8—1 *1972* 2H10—1 2F12—1

Scaphander lignarius (L.) *1971* B8—1

Class Pelecypoda

Abra alba (Wood) *1971* D3—147 C4—42 D4—111 E4—6 F4—41 G4—49 H4—48 I5—5 A6—20 B6—65 C6—52 D6—41 E6—49 F6—152 G6—126 H6—18 A8—234 B8—114 C8—4 D8—1 F8—248 H8—8 J8—42 A10—11 B10—2 C10—9 D10—2 F10—4 H10—645 J10—3 C11—23 B12—41 C12—137 D12—223 F12—34 H12—20 J12—197 Z13—8 A13—85 B13—91 C13—188 Z14—69 A14—137 B14—59 D14—3 H14—1 J14—288 Z15—272 A15—36 B15—1 D15—1 J15—246 *1972* 2D4—5 2B6—3 2G6—1 2I6—12 2DL—32 2D8—2 2C10—1 2H10—21 2V12—4 2B12—12 2F12—2 2D13—1 2A14—37 2J14—329 2X15—4 2Z15—9 2C15—1

Abra prismatica (Montagu) *1971* C4—1 F4—5 B6—2 H6—1 B8—2 F10—3 D13—1 D14—1 H14—1 D15—4 *1972* 2U15—2 2E17—4 2G18—4

Abra tenuis (Montagu) *1971* A10—1 B12—1

Acanthocardia echinata (L.) *1971* E6—1 F6—1 Z13—1

Astarte triangularis (Montagu) *1971* D15—1

Chlamys opercularis (L.) *1971* A15—1

Cochlodesma praetenue (Montagu) *1971* J8—1 H12—1

Corbula gibba (Olivi) *1971* G4—1 D6—1 H6—1 B8—1 H10—1 F12—2 D13—1 J15—1 *1972* 2DL—6 2H10—2 2D13—3 2E17—6

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* computed as *N. rubrum* and *N.* sp.

** re-identification suggested one was *Endeis laevis* (Grube)

Cultellus pellucidus (Pennant) *1971* D3—1 C4—1 G4—1 H4—2 I5—1 F6—2 G6—1 A8—1 B8—3 F8—2 J8—4 H10—12 H12—1 H14—1 J14—5 A15—2 D15—1 J15—8 *1972* 2H10—4 2B12—1
Donax vittatus (Da Costa) *1971* C4—1 B10—1
Dosinia sp. *1971* F4—1 H4—2 I5—1 H6—2 B8—1 J8—2 H10—1 C11—1 A14—2 A15—1 J15—1 *1972* 2I6—2 2DL—12
Ensis ensis (L.) *1971* D3—?1 I5—?1 C6—1 D6—?1 E6—1 G6—5 (? + 1) B8—12 F8—1 H8—?1 J8—5 B10—1 H10—?1 H12—?1 H14—?1 *1972* 2D8—1 2F12—1
Gari fervensis (Gmelin) *1971* I5—1 C6—3 G6—2 B8—1 A10—1 F10—1 H10—1 J10—1 C11—2 F12—2 H12—1 B14—1 A15—1 J15—1 *1972* 2J14—1 2V15—4
Lamellibranchia spp. *1971* F4—1 F8—1 Z13—2
Lucinoma borealis (L.) *1971* J8—1 C11—2 D12—2 J12—1 Z13—1 A13—2 B13—1 C13—3 D13—1 Z14—1 A14—3 B14—1 J14—2 Z15—1 A15—1 *1972* 2I6—?2 2DL—6 2H10—1 2J14—2 2Z15—1
Mactra corallina (L.) *1971* A8—1 C8—1 J15—1 *1972* 2D4—?1 2G6—1 2I6—2
Montacuta ferruginosa (Montagu) *1971* A15—11 B15—2 *1972* 2F12—7 2Z18—2
Mya arenaria L. *1971* C11—2 C12—8 D12—1 J12—9 Z13—13 A13—23 B13—14 C13—1 Z14—7 A14—12 J14—8 Z15—3 A15—15 J15—5 *1972* 2I6—2 2A14—1 2J14—3 2X15—2 2Z15—3
Mysella bidentata (Montagu) *1971* D3—2 C4—1 E4—1 F4—1 H4—1 I5—1 E6—1 A8—5 B8—1 D8—1 F8—1 A10—5 H10—10 C11—4 B12—11 C12—5 D12—8 Z13—7 A13—8 B13—1 C13—10 Z14—16 A14—21 J14—4 Z15—14 A15—4 J15—3 *1972* 2B6—1 2G6—2 2I6—8 2DL—8 2D8—1 2H10—4 2V12—8 2B12—21 2A14—39 2J14—37 2V15—50 2Z15—2
Mytilidae spp. (mostly juv.) *1971* D3—1 D4—1 H4—1 B6—3 B8—1 D8—1 H10—5 C11—1 J12—3 Z13—1 A14—1
Nucula nucleus (L.) *1971* B11—1 C11—2 C12—2 D12—2 J12—223 Z13—33 A13—66 B13—63 C13—20 Z14—122 A14—213 B14—26 J14—1 Z15—80 A15—3 J15—57 *1972* 2A14—78 2J14—20 2Z15—10
Nucula tenuis (Montagu) *1971* H10—1 J14—3 *1972* 2DL—2 2J14—4
Nucula turgida Leckenby & Marshall *1971* D3—6 C4—3 D4—6 E4—11 F4—18 G4—12 H4—14 I5—10 A6—1 B6—2 C6—12 D6—20 E6—182 F6—147 G6—78 H6—6 A8—15 B8—6 C8—11 D8—46 F8—160 H8—153 J8—121 C10—1 D10—5 F10—101 H10—116 J10—121 C11—1 B12—2 F12—15 H12—91 J12—41 Z13—2 H14—4 J14—14 A15—2 *1972* 2B6—24 2G6—57 2I6—2 2DL—26 2D8—51 2C10—2 2H10—100 2V12—4 2F12—17 2J14—35 2V15—22 2X15—2
Parvicardium ovale (Sowerby) *1971* A14—1
Spisula elliptica (Brown) *1971* C4—1 F4—1 I5—1 G6—1 H12—1 B14—1 D14—1 H14—1 B15—1 *1972* 2B6—1 2U15—2 2V15—4 2C15—1 2Z18—2 2G18—2
Tellina fabula Gmelin *1971* D3—8 C4—4 D4—14 E4—1 F4—12 G4—13 H4—2 I5—28 A6—1 B6—13 C6—27 D6—11 E6—16 F6—18 G6—13 H6—5 A8—12 B8—39 C8—8 D8—9 F8—10 H8—3 J8—8 A10—40 B10—10 C10—27 D10—25 F10—30 H10—16 J10—9 B11—2 C11—15 D11—5 F12—21 H12—3 H14—17 J14—7 A15—21 B15—1 D15—2 J15—17 *1972* 2B6—38 2G6—23 2I6—2 2DL—70 2D8—32 2C10—47 2H10—29 2B12—1 2F12—39 2A14—4 2U15—6 2X14—4 2Z15—8 2Z18—4 2G18—8
Tellina tenuis Da Costa *1971* A15—1
Thracia phaseolina (Lamark) *1971* G6—1 A10—2 J14—1 Z15—1 *1972* 2G6—4 2I6—4 2H10—2 2F12—3
Thyasira flexuosa (Montagu) *1971* D3—8 D4—11 F4—1 B6—2 D6—1 E6—3 F6—5 G6—2 B8—3 F8—28 H8—6 F10—1 H10—84 J10—2 C11—1 C12—4 D12—2 F12—1 H12—2 Z13—2 A13—1 C13—9 Z14—4 A14—1 B14—1 H14—1 J14—19 Z15—7 A15—1 J15—9 *1972* 2G6—4 2I6—2 2DL—8 2H10—116 2V12—2 2B12—1 2F12—5 2A14—3 2J14—40 2V15—4 2Z15—3
Venerupis pullastra (Montagu) *1971* J12—2 A13—2 B13—1 Z14—7 A14—14 B14—2 Z15—6 A15—1 *1972* 2A14—6 2Z15—1
Venus fasciata Da Costa *1971* J12—1
Venus striatula Da Costa *1971* C4—2 D4—1 F4—3 G4—2 I5—2 A6—6 B6—3 C6—14 D6—3 E6—1 F6—5 A8—6 B8—8 C8—2 F8—10 J8—3 A10—1 C10—2 D10—1 F10—3 H10—6 J10—7 C11—7 H12—2 C13—2 Z15—1 J15—3 *1972* 2D4—1 2B6—4 2G6—5 2DL—18 2H10—3 2B12—1 2F12—1 2J14—1 2V15—4

Phylum Phoronidea

Phoronis mülleri De Selys-Longchamps *1971* F4—1 G4—2 I5—1 D6—1 E6—2 F6—4 G6—4 H6—6 D8—1 F8—2 H8—1 D10—1 H10—9 J10—1 H12—1 J12—4 C13—2 Z14—2 J14—6 Z15—3 A15—3 C15—1 J15—11 *1972* 2B6—2 2G6—2 2DL—8 2H10—31 2V12—2 2B12—1 2F12—1 2D13—1 2J14—6 2Z15—2

Phylum Polyzoa

Alcyonidium gelatinosum (L.) *1971* D13 A15
Alcyonidium parasiticum (Fleming) *1971* H6 B8 C8 J8 F10 B11 C11 C12 D12 J12 A13 C13 A14 C14 J14 Z15 A15 J15 *1972* 2I6 2V12 2B12 2D13 2V15 2X15 2Z15
Flustra foliacea (L.) *1971* D4
Polyzoa spp. *1971* J12 D14 *1972* 2B12

Phylum Echinodermata

Class Asteroidea

Asterias rubens L. *1971* A13—3 C13—1 Z14—1 *1972* 2B12—1 2X15—2

Class Ophiuroidea

Acrocnida brachiata (Montagu) *1971* C4—1 E4—2 F4—1 G4—2 I5—2 B6—1 D6—1 E6—1 F6—1 H6—1 A8—1 B8—3 F8—1 J8—2 A10—4 B10—1 C10—1 F10—3 H10—2 J10—2 B11—1 C11—1 F12—1 *1972* 2B6—1 2G6—1 2DL—2 2H10—2 2V15—2
Amphipholis squamata (Delle Chiaje) *1971* Z13—1 A13—2 A14—5 *1972* 2V12—2
Ophiothrix fragilis (Abildgaard) *1971* B11—2 C11—1 D11—1 J12—1 Z13—3 Z14—1 A14—2 J14—10 A15—1 *1972* 2A14—14 2J14—26
Ophiura albida Forbes *1971* D4—1 E6—2 D8—2 F8—2 J8—2 B10—1 H10—12 J10—1 F14—2 H14—1 *1972* 2DL—2 2H10—11
Ophiura sp. (small)* *1971* G4—1 I5—2 F6—2 A8—1 B8—3 C8—1 F8—1 B10—1 H10—8 B11—1 F12—1 A15—1 *1972* 2DL—2 2H10—1 2B12—1 2U15—2 2V15—2
Ophiura texturata Lamarck *1971* G6—4 F8—1 J10—1 *1972* 2G6—1
Ophiuroidea spp. *1971* A10—1 J12—1 *1972* 2Z18—2

Class Echinoidea

Echinocardium cordatum (Pennant) *1971* H6—1 D13—4 B14—1 H14—?1 A15—2 B15—3 *1972* 2F12—1 2D13—1 2V15—?2 2E17—4 2Z18—4
Echinocardium flavescens (Müller) *1971* F14—1

Class Holothurioidea

Leptosynapta inhaerens (Müller) *1972* 2J14—1

Phylum Chordata

Sub-Phylum Tunicata

Class Ascidiacea

Ascidiacea spp. *1972* 2V12—2 2V15—2 2Z15—1
Dendrodoa grossularia (Van Beneden) *1971* J12—18 Z14—4 *1972* 2A14—6
Pelonaia corrugata Forbes & Goodsir *1971* C13—1

Sub-Phylum Vertebrata

Class Pisces

Ammodytes tobianus L. *1971* D11—1
Pholis gunnellus (L.) *1972* 2J14—1
Teleostii sp. (larva) *1971* D8—1

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* mainly, if not entirely, *O. affinis* Lutken. Possibly a few juvenile *O. albida*.